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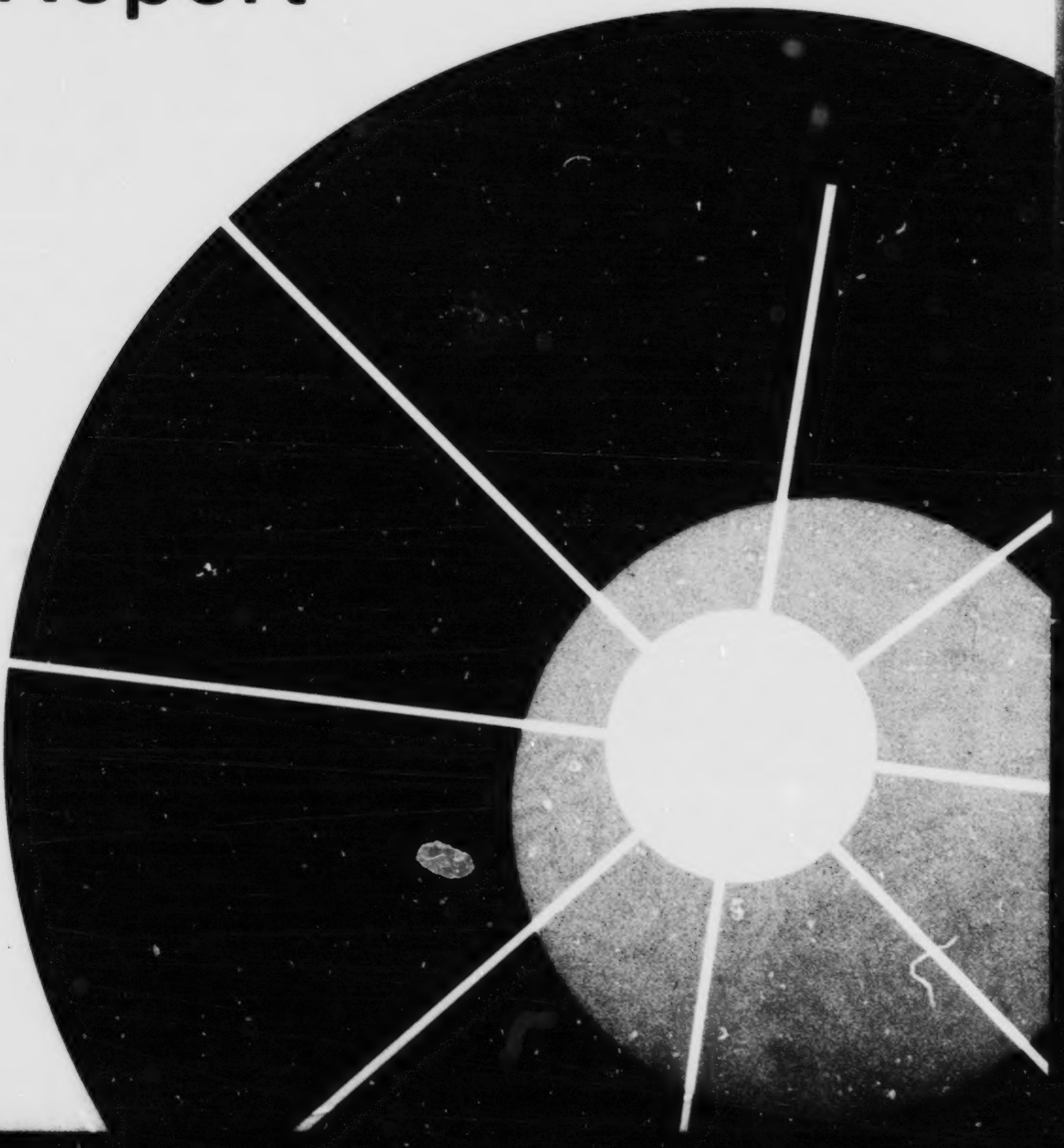
Canada - Saskatchewan Renewables — Conservation Demonstration Program

Final Report



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CANADA-SASKATCHEWAN CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

On March 18, 1980, the governments of Canada and Saskatchewan entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement, which terminates March 31, 1984, funds the development and demonstration of a wide range of conservation and renewable energy technologies. The program is funded on an equal cost-shared basis by Canada and Saskatchewan, and is administered by Saskatchewan.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies which exploit renewable energy resources, conserve energy, or make its use more efficient;
- To create employment in new or existing industries;
- To develop broad public awareness of the potential of renewable energy and energy conservation technologies.

This report outlines the results of a project funded by the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, and the Government of Canada as represented by Energy, Mines and Resources Canada, under the terms of the Renewables-Conservation Demonstration Program, and contracted with the party identified herein.

However, neither the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, nor the Government of Canada as represented by Energy, Mines and Resources Canada, accept liability for any errors, omissions, or inaccuracies that may; be included in or derived from this report, nor do they assume any liability with respect to the use of, or actions resulting from the use of, any information contained in this report.

SASK. 29

Fuel Peat for Residential Furnaces

Final Technical Report
on a Renewables-Conservation Demonstration Program Project

Conducted By

Saskatchewan Energy and Mines

And Supported By

Saskatchewan Energy and Mines
and
Energy Mines and Resources Canada

Project Leader: Paul Guliov

Miscellaneous
Report FP-33

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INTRODUCTION AND OBJECTIVES

PART 1 - INTRODUCTION AND OBJECTIVES

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1.0 INTRODUCTION AND OBJECTIVES

1.1 BACKGROUND

In order to include information on activies leading up to fuel peat demonstration test, a number of direct extracts including the previous field investigations and site selection from previous reports have been incorporated into Parts 1,2 and 3. This approach should give the reader a better overall picture of all the aspects of research and survey work needed to establish a peat industry.

The reports quoted are entitled "Assessment of the Technical and Economic Feasibility of Peat Resource Development in Northern Saskatchewan Communities" and "Buffalo Narrows Peat Utilization Study" submitted to the Government of Saskatchewan, Department at Mineral Resources by Saskmont Engineering Company Limited in 1979 and 1981, respectively. No further acknowledgement to the reports is made in the text.

Several recommendations were made in the earlier reports including the following:

"Technical Feasibility: it was found that the most technically attractive conversion systems are for domestic heating and it is recommended that this market be studied further."

"Economic Feasibility: it is recommended that sod peat production be considered in the region of Buffalo Narrows, Ile-a-la-Crosse, Canoe Narrows and Beauval since the economics of small-scale peat utilization show the greatest promise in the area. On the basis of economics and cost, it is recommended that sod peat mining be used for domestic and commercial furnace fuel supply. The minimum economic size for a sod peat operation is about 50 ha, which would be large enough to supply domestic heating fuel for 200 units."

"Preferred Peat Production and Utilization Schemes: the findings have indicated that four schemes are sufficiently attractive both technically and economically to warrent further resource and site specific economic studies - the equipping of new homes with peat-modified multi-fuel furnaces and the conversion of existing wood stove, multi-fuel, solid fuel and oil furnaces to sod peat firing."

"Preferred Areas for Resource Study: it is recommended that the region within 25-50 km of the communities of Buffalo Narrows, Ile-a-la-Crosse, Canoe Narrows and Beauval receive first priority for peat resource inventory programs for sod peat production."

During the summer of 1979, SMR personnel started a peat reconnaissance survey program in northern Saskatchewan. This program, which also included the Buffalo Narrows region, consisted of locating and investigating bogs of interest (areal extent, depth, and basic peat quality information). The program has produced a large quantity of data useable as a foundation for further investigations.

A logical outgrowth of the previous work, a second investigation commenced in September, 1980 with the purpose of determining the economic viability of fuel peat (and moss peat) production and utilization in the Buffalo Narrows area including costs of distribution and conversion of existing heating systems. SMR also requested that the need for a practical demonstration project to test the economic and technical aspects of a locally-based fuel peat industry be evaluated.

This second project was a more in-depth study and produced the following assessment:

1. "The extent and volumes/tonnages of peat in the Buffalo Narrows region of Saskatchewan are very large and are capable of supporting large-scale fuel peat production operations. A bog suitable for both demonstration and commercial peat production was located near the junction of Highway 155 and the Dillon Road, south of Buffalo Narrows."

2. "The peat type, degree of humification, chemical composition and bulk density of the peats analyzed indicate that northern Saskatchewan peatlands contain large quantities of excellent quality fuel peat. The quality of fuel peat in this region compares well with, and often exceeds, that of many European fuel peats".

3. "While drainability may cause problems in certain low-lying areas, most of the large fuel peat deposits surveyed in the region appear sufficiently capable of being drained to accommodate standard dry mining equipment."

4. "The preliminary nature of the surveys precluded a detailed study of large areas of peatland. Work to date by Monenco's peat specialists has shown that moss peat, suitable for horticultural purposes, is not as common as fuel peat in the Buffalo Narrows area. However, there are indications from the preliminary airphoto analyses, that a detailed airphoto and ground survey program may outline sufficient areas of moss peat that could form a basis for a viable horticultural peat industry."

5. "The study established that a suitably sized domestic heating market exists in the Buffalo Narrows region. Buffalo Narrows and the nearby area have a current potential annual peat

requirement of 1,200 to 2,500 tonnes depending on the percent utilization of peat in existing wood and multi-fuel furnaces and the combustion efficiency of peat relative to other fuels. Including the other communities in the region (Beauval, Ile-a-la-Crosse, La Loche), there is potential for supporting a sod peat operation with total annual production of 3,240 to 7,300 tonnes, depending on percent utilization of peat and combustion efficiency. These markets are expected to grow closely corresponding to increases in population."

6. "The firing tests of Finnish peat sods and briquets carried out by the two major suppliers of domestic furnaces for the Department of Northern Saskatchewan (DNS), showed that both briquets and sods ignited and burned comfortably. Indications are that the furnace without a grate may have advantages in controlling the burn of peat sods. This aspect, and a number of other findings require further investigation under actual field conditions. A demonstration firing test in a number of properly monitored DNS constructed dwellings for a complete heating season was recommended. It was recommended that a furnace specifically designed to burn peat (possibly of European or American manufacture) be installed in a DNS dwelling for comparison tests."

7. "The climatic analyses show that the Buffalo Narrows area has a suitable climate for peat production using the existing dry mining methods. The shortness of the frost-free period is compensated for by a high water deficiency, high potential evapotranspiration, high number of sunshine hours and low precipitation.

   The climatic data indicates that the potential rate of production should be equal to, and possibly exceed, that attained in eastern Canada where high precipitation, cooler temperatures and often unpredictable weather can create conditions which hamper peat production."

8. "Sod peat mining is best suited for the small-scale production of fuel peat given the prevailing climatic conditions with certain unknown day-to-day weather factors. Peat sods are also considered the most practical fuel for use in the exsiting multi-fuel and wood furnaces.

   Most of the basic pieces of equipment needed for the mining operation are available either locally or elsewhere in Canada. Pieces not made in Canada can be imported and their availability and suitability has already been proven for Canadian conditions."

9. "The estimated capital costs included the purchase and delivery of equipment and buildings, road construction, site preparation, bog surveys, bog drainage and project management and supervision for the development work. Total estimated capital costs for the 4,000 tonnes per year fuel peat operation was $344,800. The production equipment has unused capacity and the same equipment can be utilized to produce 6,000 tonnes per year by expanding to the nearby bogs."

   "The annual operating costs include labour, supervision, equipment maintenance and spares, equipment rentals, was $154,400 annually for loose sod peat f.o.b. bogside."

10. "In this study, oil was used as a base fuel for estimating heat requirements for dwellings in the Buffalo Narrows area. The costs of other energy sources such as electricity, wood and fuel peat are compared below and they include assumptions of heating efficiency relative to oil."

Domestic Fuel	Production Level (tonnes/year)	$ per Million kJ 1981	Heating Efficiency Relative to Oil
Electricity	N/A	7.63	10% greater
Oil	N/A	5.93	-
Wood	N/A	3.76	10% less
Sod Peat	4,000 tpy Loose	2.92 to 3.29	10%-20% less (respectively)
	Bagged	4.67 to 5.26	10%-20% less (respectively)
	2,000 tpy Loose	5.29 to 5.95	10%-20% less (respectively)
	6,000 tpy Loose	2.42 to 2.72	10%-20% less (respectively)

(This table is taken directly from the Buffalo Narrows Peat Utilization Study (1981) and gives a relative picture of the costs of various fuels at the time of the study.)

"The unit costs of peat shown above were based solely on operating costs, without an allowance for capital charges. On this basis, peat is competitive with oil and electricity in all cases. In comparison to wood a distinct advantage did not exist. Depending on the heating efficiency of peat, the form in which peat is sold and the final peat production rate of the bog operation, peat shows the possibility of becoming competitive. It is apparent that bagging peat adds considerably to the cost. Further investigations were recommended regarding the most appropriate packaging technique."

11. "Peat is an environmentally clean fuel in comparison with conventional fossil fuels. The analysis of the peats in the Buffalo Narrows region indicates that, as far as pollutants

such as sulphur and mercury from the combustion of peat in domestic furnaces are concerned, no increase in pollution level is expected.

The analysis of a number of other elements also showed that the values are within limits analysed elsewhere and found to be environmentally acceptable, and below levels that might be considered hazardous.

The low ash content also makes the peat a suitable fuel, when considering pollution aspects. The fly ash from a large peat-fired power station could cause problems. However, for domestic use, the high density of peat ash, in comparison, for example, with wood ash, further diminishes the possibilities of nuisance caused by airborne ash emissions.

The selected demonstration bog is located far enough from main water bodies to allow the drainage waters to seep through an adjacent peatland to filter out possible suspended peat silt and prevent it from entering potentially good fishing waters. The small quantities of drainage water will otherwise have no significant influence on the adjacent water quality."

12. "The sod peat mining method is proven technology elsewhere. Sod peat is burned in Finland and Ireland for domestic heating. A demonstration project is recommended to be carried out on the same bog proposed for commercial development. Its purpose is to introduce sod peat mining technology to the north central area of Saskatchewan and to evaluate its performance under Saskatchewan conditions."

1.2 PROJECT OBJECTIVES

The findings of the initial work led to a recommendation to carry out a demonstration project with the main objectives being:

- "to determine the suitability of peatland, peat type, and climate/weather in the Buffalo Narrows area for the production of fuel peat using a 25 ha demonstration bog as a test site;"

- "the testing of a conventional fuel peat mining method, namely extruded sod peat. Sodding characteristics of the peat will be determined as well as the drying rates achievable under local conditions";

- "to obtain preliminary information on peat production rates and costs to assist in preparing an estimated cost of mining for a commercial-size operation;"

- "to determine the suitablility of sods as a fuel for domestic heating in terms of handling, storage, combustion characteristics, efficiency, burn rate and other factors affecting consumer acceptances;"

- "to evaluate the general suitability of both Canadian and Finnish domestic furnaces for burning sod peat in terms of basic performance characteristics of the units."

PART 2

RESOURCE INFORMATION

PART 2 -- RESOURCE INFORMATION

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2.0 RESOURCE INFORMATION

2.1 DEMONSTRATION SITE DESCRIPTION

211 INTRODUCTION

A number of factors were considered in selecting the demonstration bog. One of the main aspects to be emphasized is, that the project was a demonstration trial, not a commercial project. Consequently, the size and peat thickness played a less important part in the site selection while more attention was given to the distance from the user and good access to the bog. However, to ensure future supplies of suitable peat for a larger scale commercial operation, a back-up bog with a larger quantity of peat was selected. Figure 2-1 is a general location map showing the test site near Buffalo Narrows, Saskatchewan.

The main points considered in the site selection were the distance from the user, access, site elevation and drainability, vegetation and bog type, peat types and the degree of humification, peat quality and quantity, climatic suitability and the basic environmental implications. The following chapters describe the demonstration bog and include the main aspects of resource information obtained during the earlier phases of peat investigations.

212 BOG SELECTION

To determine the best location for a potential demonstration site, Monenco personnel, with the co-operation of SMR staff and the aid of the SMR preliminary survey data, performed further reconnaissance work on a number of peatlands in the Buffalo Narrows area to select a bog (or bogs) which offered potential for a fuel peat operation. A strip of land along Provincial Highway 155 (about 25 km north and 75 km south of Buffalo Narrows, and 10 - 15 km to the west of the highway and 2 - 8 km east to the first large river) was selected for examination, as an area which offered a reasonable transport distance. A number of bogs were selected from the SMR survey. Bog sizes varied from about 30 ha up to several hundred hectares with overall peat thickness ranging from 1.5 to 5 m. These bogs contained well-humified peats (H4 or over) and were considered for further fieldwork.

The final selection was made by visiting each of the sites in order to sample the peat, observe the site and in general, to assess the accessibility and drainability of the deposit. Travelling was done by a helicopter. A number of the pre-selected bogs were judged either too heavily treed, too difficult to reach by surface transportation, or too difficult to drain to be selected as a demonstration bog.

Bogs No. 31 and 166 were selected as best fulfilling the requirements of a fuel peat operation as far as access, size, peat type, quantity, etc. were concerned. Bog No. 166 was selected as a back-up for a possible larger scale commercial operation in the future.

213 LOCATION, ACCESS AND DRAINABILITY

Bog 31 is located immediately east of Highway 155 (Figure 2-2). The northwestern corner of the bog touches the highway while the rest of the western edge of the bog is within 200 meters of the highway. Figures 2-3 and 2-4 shows the demonstration site from the air. The bog is about 10 km south of Buffalo Narrows and within a reasonable distance from possible users. The bog is adjacent to sizeable peatlands to the east which offer potential for expansion. The peat type in the adjacent bogs appears to be of suitable quality for fuel use.

According to the topographical maps, Bog 31 is located on a nearly level height of land. A thorough survey of the surface elevations along the perimeter and field ditches was carried out in September 1982 to determine the extent of future drainage work required. Figures 4-39 to 4-42 show the elevations in detail. The field ditch profiles show that the bog is quite flat, lying slightly above 432 m a.m.s.l. There is no significant gradient across the bog along the field ditches (Figures 4-41 and 4-42).

Figure 4-39 reveals that there is a slight gradient along the western perimeter ditch towards the northeast to the adjacent bog into which this perimeter ditch flows. The total drop in the elevation along this ditch is about 1 m until the ditch reaches the edge of the bog about 1,000 meters from the demonstration fields. During the last 60 to 70 meters the surface of the bog quickly drops another 1.5 m to the level of the next deposit which is slightly below the approximate elevation of the base of the demonstration bog. By deepening the perimeter ditch drainage can be improved further.

Figure 4-40 shows that there is a slightly greater elevation difference between the surface of the demonstration bog and the bog to the east of it. The difference is more than 3 m. The illustrations indicate that while the bog itself is quite flat, it is drainable due to a significant elevation difference between the demonstration bog and the adjacent terrain.

214 VEGETATION AND BOG TYPE

As a rule, the most prominent feature of the Buffalo Narrows peatlands is their minerotrophic character. Most peatlands in the region are, regardless of size, quite flat and in the airform pattern study sense, featureless. According to airphoto interpretation criteria, they belong mostly to Dermatoid or Stipploid pattern groups (Radforth, 1956) as far as high altitude airform patterns are concerned. A Reticuloid pattern appeared occasionally, but is relatively low in frequency. Dermatoid and Stipploid airform patterns can be related to ground conditions where minerotrophic fens are prevalent with occasional treed areas and string bog areas mixed with sedge cover.

The demonstration site exhibited both Dermatoid and Stiploid characteristics. It is composed of sedge-fen types of open vegetation and trees mixed with high to low shrub fen areas. The open sedge areas are located at the northwestern part of the bog, and in smaller areas in the central part of the bog (Figure 2-5). The balance of the bog is covered by trees of varying sizes. The densest and largest (up to 5 m high, 10 cm in diameter) trees are located at the southern part of the bog (see Figure 2-6). The tree cover is composed of _Larix laricina_ and _Picea mariana_ with _Kalmia_, _Ledum_ and other shrubs in the understory with sphagnum mosses as a universal mat throughout.

215 PEAT TYPES AND DEGREE OF HUMIFICATION

Regionally, the bogs studied appear to contain peats where sphagnum predominates only as a thin surficial layer. On average, the moss peat layer is about 0.9 m thick in the bogs drilled during the selection survey and is composed of a layer, where peats are predominantly sphagnum, with a degree of humification of H3 or less and thus, not suitable for energy purposes. Almost invariably H4 peats in this region are predominantly composed of sedges, and suitable for energy purposes. Among the bogs sampled to locate the demonstration bog, the sphagnum layer reaches thicknesses of 1.5 m in Bogs 35 and 63 which can be considered suitable for moss peat production.

The demonstration bog has a moss peat cover ranging from 0.3 to 0.7 m and averaging about 0.5 m. The less humified surface layer is composed mainly of sphagnum, however, its proportion may be slightly higher than actual values. The reason for this lies in the characteristics of the Hiller auger which tends to leave more fibrous sedge constituents in the ground at the lower degrees of humification. At depths below the surface mat (about 0.5 m thick), sedge peat dominates. Up to 80% of the peat is composed of sedges and 20% of sphagnum. The degree of humification in the demonstration bog is high and indicates good fuel properties.

Below the surface mat well-humified peat layers with an average thickness of 1.2 m exist throughout the entire mineable area. The minimum thickness of well humified peat in the mineable area is 0.5 m and the maximum is 1.9 m. The average degree of humification for this layer is H6.3 in the demonstation bog. This compares favourably with the general area, where the minimum found at the sites sampled was H4.4, and the average was H5.7 (Table 2-1). The high average degree of humification and the shallow thickness of the surface mat makes the peat very suitable for fuel purposes. In comparison with eastern Canada, the Saskatchewan peatlands (in the Buffalo Narrows area) can be considered as fuel peat bogs, while the eastern (Maritime) Canadian bogs are moss peat types.

216 PEAT QUALITY BASED ON LABORATORY ANALYSIS

The results of the laboratory analyses confirmed the field observations. The results are compared with those of European fuel peats in order to give an indication of the quality of Saskatchewan peat as a fuel in comparison with well-established fuel peats.

TABLE 2-1
Data from Bogs Selected for Further Reconnaissance Sampling

Bog No.	Average Thickness of Moss Peat	Average Thickness of Fuel Peat	Average Degree of Humification: Fuel Peat	Average Degree of Humification: Total Profile
31	0.5	1.2	6.3	4.9
166	0.6	1.4	5.7	4.7
15	N/A	0.6	4.7	3.6
35	1.5	1.0	6.0	3.5
51	1.1	1.4	6.4	4.8
58	1.0	3.3	6.1	4.9
63	1.5	1.5	6.1	4.6
148	0.9	1.6	4.4	3.6
AVERAGE: ALL BOGS	0.9	1.5	5.7	4.4

NOTE: Figures for Bogs 15, 35, 51, 63 and 148 cannot be regarded as bog averages since they represent values for one sample site.

TABLE 2-2
Analyses* of Peat Samples from Bogs 31 and 166

	BOG 31				BOG 166		
	Site 3			Site 4	Site 4		
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 1	Sample 2	Sample 3
Moisture Content (% wet weight)	89.8	85.1	86.8	86.4	91.0	90.0	87.3
Ash Content (% dry matter)	3.5	3.2	4.5	3.8	4.8	4.8	6.4
Volatile Matter (% dry matter)	73.0	70.6	67.7	69.3	70.9	70.0	64.0
Sulphur (% dry matter)	0.10	0.13	0.15	0.15	0.11	0.2	0.24
Mercury (ppm)	0.7	0.5	0.5	0.05	0.08	0.07	0.06
Calorific values (kcal/kg)	5093	5313	5349	5420	5215	5210	5051
Bulk Density As Received (kg/m^3)	285	328	345	240	238	303	288
Bulk Density at 50% moisture content (kg/m^3)	200	235	235	200	160	235	200
pH	4.1	4.2	4.5	4.6	5.0	5.1	5.0
von Post Degree of Humification	5	6	8	8	5	6	8
Peat Type	SC	SC	SC	SC	C	NC	LSC

*Analyses performed at Canmet Laboratories

TABLE 2-3
Comparison of Various Fuels

	Heavy Fuel Oil	Coal (Bituminous)	Coal (Lignite)	Peat	Wood
C %	83-86	76-87	65-75	50-60	48-50
H %	11.5-12.5	3.5-5.0	4.5-5.5	5.0-6.5	6.0-6.5
O %	1.5-2.5	2.8-11.3	20-30	30-40	38-42
N %	0.1-0.3	0.8-1.2	1-2	1.0-2.5	0.5-2.3
S %	2.0-2.8	1.0-3.0	1-3	0.1-0.2	
Ash Content %	0.3	4-10	6-10	2-10	0.4-0.6
Melting Point of Ash °C		1100-1300	1100-1300	1100-1200	1350-1450
Volatiles %		10-50	50-60	60-70	75-85
Specify Gravity kg/m^3	920-970	720-880	650-780	300-400	320-420
Effective Heat Value (Dry Matter) kcal/kg	9900-10,000	6800-7900	4800-5800	4700-5100	4400-4600
Btu/lb.	(17,800-18,000)	(12,250-14,250)	(8650-10,450)	(7930-8290)	(7930-9290)
Operational Moisture %	0.1	3-8	40-60	40-60	30-55
Effective Heat Value at the Lowest Operational Moisture Content, kcal/kg		6570-7640	2640-3240	2500-3000	2900-3040
Effective Heat Value at the Highest Operational Moisture Content, kcal/kg		6200-7220	1560-1960	1780-1960	1650-1740

Table 2-2 gives the results of a number of analyses carried out on the peat from Bogs 31 and 166 (back-up bog). The ash content is low, averaging 3.8% for Bog 31. The ash levels fall within the usual limits of 2 - 10% as measured for European fuel peat (Table 2-3).

The in-situ moisture content varied from the high 80's to low 90's(%). These values should be approached with caution since the sampling was done by Hiller auger, where the loss of moisture at the time of sampling can be considerable. To obtain more reliable values, time-consuming sampling with a piston sampler would have to be carried out.

The volatile matter averaged 70.1% for Bog 31. The value is relatively high in comparison with European fuel peat containing 50 - 60% V.M. (Table 2-3). The high amount of volatile matter should be confirmed with additional sampling, and considered in possible furnace modifications. The level of fixed carbon in the samples reflected those measured elsewhere.

Average sulphur content is 0.13% for Bog 31. European values commonly range from 0.1 to 0.2% indicating a similarity with the Buffalo Narrows peat. The lower sulphur content is one of the advantages of peat as fuel, from the pollution control point of view.

The average dry calorific value for Bog 31 was 5293 kcal/kg (9540 Btu/lb.). In comparison with European fuel peat, the values are higher than the upper limits which are about 5100 kcal/kg (9190 Btu/lb.) but slightly lower than that of lignite, 5800 kcal/kg (10,450 Btu/lb.).

The content of mercury was also measured. The values are low and are dealt with in more detail in Section 8, "Environmental Considerations".

The average bulk density at a 50% moisture content was measured at 217.5 kg/m^3. The analyser, however, warned that due to the small size of the samples, the values cannot be considered reliable. Experience has shown that with small samples the bulk density values tend to be be lower than with large samples. This is inherent in the simple, non-standardized method of making the measurements. However, the values still indicate that the peat in Bog 31 is expected to be composed of good grade fuel peat, as far as bulk density is concerned.

All these values recorded for Saskatchewan peats are comparable with those elsewhere in Canada. The calorific values actually are relatively high in comparison with eastern Canada in general.

217 PEAT QUANTITIES

Figure 2-7 shows the outline of the demonstration bog and the peat isopachs. The base map used for preparing isopachs, conceptual plans, etc., was based on available airphotos.

The total area of the bog is 40 ha, of which 30 ha are covered by the mine plan and of which 24 ha are within the one meter isopach considered as the outer limit of the mineable area. The maximum depth of the bog is 2.3 m. The area of peat thickness 1 m or over is 24 ha, and 2 m or over is 6.5 ha.

The total peat volumes are listed in Table 2-4. According to the calculations, the bog contains a total of about 472,500 m^3 of peat. Of this total 80,000 m^3 are in areas less than 1 m thick, and may not be mineable. The mineable area (1 m or more in thickness) contains 392,500 m^3 and is the area with a peat thickness of 1 m or more. The volumes stated are in-situ resource values and do not necessarily reflect the final recoverable volumes.

The tonnage calculations are based on the assumption that the average density of 217.5 kg/m^3 (based on four bulk density measurements) at a 50% moisture content is valid for the entire deposit. Table 2-4 shows the entire deposit to contain a total of 102,533 tonnes of peat of which 85,172 tonnes are potentially mineable (in areas greater than 1 m thick).

TABLE 2-4

Resource Data on the Demonstration Bog

Area Description	Area ha	Volume m^3	Tonnes at 50% Moisture Content (at average 217 kg/m^3)
Total Bog	40	472,500	102,533
1 m thick	16	80,000	17,360
1 m thick (potentially mineable portion)	24	392,500	85,173
1-2 m thick	17.5	262,500	56,963
2 m thick	6.5	130,000	28,210

Note: Due to the small number of survey points, the volume calculations have been based on the assumption that the average thickness for the area 2 m or more is 2 m, for the area 1-2 m is 1.5 m, and for the area less than 1 m is 0.5 m.

The recoverable quantities depend on the surface area available for mining and the mining techniques used. Based on the preliminary analysis of the climatic conditions at Buffalo Narrows, it is estimated that a production rate of 1000 m^3/ha/year can be achieved using standard milled peat technology. It is expected that a total of 24,000 m^3 can be produced annually from the mineable area of the bog. Assuming that the average bulk density of 217.5 kg/m^3 (at 50% moisture content) is valid for the entire deposit, this volume is equivalent to 5,220 tonnes of peat annually at a 50% mosture content. However, this assumes an intensive production rate averaging 217.5 tonnes/ha/year. It is expected that during the first years the lighter surface peats will reduce the tonnages to less than 200 tonnes/ha/year. Taking into consideration a further 20% mining loss and the inefficiency involved in developing a new operation, the production will likely be about 100 tonnes/ha/year or 2,400 tonnes annually in the initial production years.

Based on preliminary calculations, the demonstration bog contains sufficient quantities of peat for several years of project life. Assuming that the basal layer of 0.5 m of the deposit is not usable, the mineable volumes are about 273,000 m^3 or 59,371 tonnes. This represents about 18.5 years of production using the milled peat method, at an annual production rate of 3,200 tonnes. Using the sod peat method at an annual production rate of 2,400 tonnes, the bog life is about 25 years. However, the deep cutting principle of the sod machinery can shorten the mine life considerably.

218 MOSS PEAT OPTION

As far as the demonstration bog is concerned, the quantity of moss peat in the thin (moss peat) surface layer is not sufficient to support the production of horticultural peat for any long time period. The quality of the top layer is suitable to produce a relatively good horticultural product because it contains insignificant quantities of sedge mixed with sphagnum which does not lower the quality parameters required for first grade horticultural peat.

While conducting the aerial reconnaissance of the peatlands in the Buffalo Narrows region, it was noted that areas of good horticultural peat were not readily evident; at least not in amounts presenting opportunities for horticultural peat operations. In order to establish an operation to produce horticultural peat, more in-depth survey work has to be carried out. While the majority of the peatlands are eutrophic, sedge bogs mostly of a fen type, there are occasional individual deposits displaying ombrogenic features, and also containing sphagnum peat of a type such as found in Bog No. 63. Also some individual deposits, while displaying eutrophic surface cover, contained large quantities of moss peat such as Bog 35.

Although sizeable deposits of horticultural peat were not readily identified, indications of the occurrence of horticultural peat were present. Further surveys may uncover the locations of suitable deposits for horticultural operations, or for the co-production of fuel and horticultural peat, should a suitable market exist.

219 CLIMATIC CONSIDERATIONS

Climate is one of the main physical controls determining the feasibility of carrying out peat mining operations. The main climatic factors affecting the establishment of a peat industry, either individually or in combination are temperature, precipitation, humidity and the length of the frost free period. Other factors, such as potential evapotranspiration, actual evapotranspiration and average annual water deficiency are useful as indicators for the suitability of the regional climate for peat mining. The consideration of all these factors must be subject to a careful interpretation, from one locality to another, since a comprehensive climatic index has not been devised yet, for the use of the peat industry.

While the climatic(1) conditions may indicate that a specific area might be suitable for a peat mining operation, day-to-day weather(2) may hamper or even occasionally preclude the operations. Thus too short a frost free period and occasional occurrence of scattered permafrost may make it impossible to mine peat in some northern areas although the mean values (e.g. precipitation and the day to day distribution of precipitation) indicate suitable climatic and weather conditions. Similarly, while a long frost free period in the Maritime regions, together with reasonably low values of precipitation may encourage the establishment of a peat industry, a high frequency of rains during the production season may make peat mining operations uneconomical.

In order to assess the basic suitability of the climate at Buffalo Narrows for peat production, the following comparison of the most pertinent climatic factors affecting peat production with those in other areas of Canada where peat is currently produced (Shawinigan, Quebec; Chatham, New Brunswick and Grand Falls, Newfoundland) was done. Comprehensive long term data were not available for Buffalo Narrows. In order to be able to interpolate data for Buffalo Narrows - Uranium City, Dorintosh and Prince Albert were selected.

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(1) Climate: The average course of weather at a particular place over a period of many years as exhibited e.g. in absolute means of weather elements.

(2) Weather: State of atmosphere at a definite time and place with respect to weather elements (e.g. temperature).

.1 Frost-Free Period

The average length of the frost-free period in eastern Canada in areas of peat production varies from about 110 to 141 days a year (see Table 2-5). In the Dorintosh-Prince Albert area it is about 90 days, while north at Uranium City, is is over 100 (106) days. An approximate interpolation between these values indicates that in Buffalo Narrows the frost-free period would be about 95-97 days, or 15 to 45 days shorter than in eastern Canada. However, it should not preclude peat production since other factors are favourable and should compensate for the shortness of the season by allowing more intensive production activity with fewer weather-related interruptions.

The short frost-free period is also an indication of the possibility of encountering lingering ground frost. In anticipation of this, one should consider mining methods and plan carefully before final commitment. For instance, milled peat operations are not as severely hampered by long lingering ground frost as sod peat operations, because the sods are produced by a machine cutting 80-100 mm into peat.

From the average dates of the last and first frosts, it appears that the prime production season in Buffalo Narrows would be between early June and late August, while in Quebec and New Brunswick it is between the middle of May until late September, and in Newfoundland between early June and late September (see Table 2-5).

.2 Average Hours of Bright Sunshine

The average hours of bright sunshine during the overall 5 month (first of May to the end of September) bog preparation and peat production season varies from a low of 850 hours in Newfoundland, to 1,050, 1,150 and 1,259 hours in New Brunswick, Quebec and Saskatchewan respectively.

TABLE 2-5
Comparison of Climatic Data

	Uranium City Sask.	Dorintosh Sask.	Prince Albert Sask.	Shawinigan Quebec	Chatham N.B.	Grand Falls Nfld.
Length of average frost free period (days)	106	90	93	141	122	110
Average date of last frost (spring)	May 30	June 4	June 5	May 13	May 22	June 7
Average date of first frost (fall)	Sept. 14	Sept. 3	Sept. 7	Oct. 2	Sept 21	Sept. 26
Average hours of bright sunshine May-September	-	-	1259	1150	1050	850
Mean daily temperatures, May-September (T°C)	11.5	12.7	13.6	16.1	15.1	12.9
Mean daily maximum temperatures, May-September (T°C)	16.6	20.2	20.7	21.8	21.1	18.3
Mean total precipitation, May-September (mm)	183	259	245	449	410	400
Potential annual evapotranspiration (mm)	500	563	566	553	544	567
Average annual water deficiency (mm)	166	155	186	21	44	36

Information obtained from references 1,2,3,4 and 5. See list of references.

While direct sunshine is not necessary for successful drying of peat in the field as long as the humidity remains low, it is a good indication of conditions favouring the solar drying of peat. In this case, the high number of hours of bright sunshine in Saskatchewan gives an indication that, regardless of a shorter frost-free period, a peat production scheme should be possible, when one compares this value with hours of sunshine for Chatham, N.B., which is 20% lower, and still provides an ample number of sunny days for successful peat operations.

.3 Temperature

The mean daily temperatures for May - September are 11.5°C, 12.7°C and 13.6°C at Uranium City, Dorintosh and Prince Albert respectively. It is estimated that about 12-12.5°C is the value for Buffalo Narrows. This is 0.5°C less than for various eastern Canadian stations, and obviously is caused by lower nightly temperatures. This is evidenced by the mean daily maximum of about 19°C which is actually higher than in Grand Falls (18.3°C) and only 2-3°C lower than in Chatham (21.1°C) and Shawinigan (21.8°C). The high daily maxima are indications of conditions favourable for the drying of peat on the field.

.4 Precipitation

Mean total precipitation for May-September varies from 183 mm in Uranium City, to 245 mm and 259 mm in Prince Albert and Dorintosh respectively. It can be safely assumed that an interpolated value for Buffalo Narrows would be about 200 mm, for the same time period. This is about 45-50% of the values listed for eastern Canadian stations (see Table 2-5). Assuming that the spring runoff takes place before the end of May, the Buffalo Narrows area appears attractive for a peat mining operation, as far as precipitation is concerned.

.5 Summary of Water Balance Data

Table 2-5 lists the potential annual evapotranspiration and the annual water deficiency for all stations discussed. The average annual potential evapotranspiration for all stations falls between 500 mm (Uranium City) and 567 mm (Grand Falls) indicating good potential for drying since the potential evapotranspiration is the amount of water that would be evaporated or transpired from surface completely covered by vegetation. However, due to the low precipitation in Saskatchewan, as compared with the Shawinigan, Chatham and Grand Falls area, the soil moisture storage volumes are low, resulting in a low actual evapotranspiration. This, combined with a relatively high potential evapotranspiration results in a moisture deficiency of varying degree. The average annual moisture deficiency is 155, 166 and 186 mm in Dorintosh, Uranium City and Prince Albert respectively, and can be assumed to be about 155 to 165 mm in Buffalo Narrows area. This compares favourably with the low values of 21, 36 and 44 mm for Shawinigan, Grand Falls and Chatham respectively.

Factors such as potential evapotranspiration have been related to specific soil storage and water holding capacities, which depend on the composition, structure and depth of the soil and the type of surface vegetation. As there are no specific data from which to calculate water balances for peat, all the above listed values are for relatively well drained soils with an assumed 100 mm moisture holding capacity. Consequently, while they give relationships between the listed locations, the values may not, without modifications, apply to peatland since peat has a very high moisture holding capacity. However, once the peatland has been drained, the potential evapotranspiration values should give an indication of the relative suitability of the area for peat mining using present mining methods, since the mined peat at the surface is no longer in contact with the ground-water.

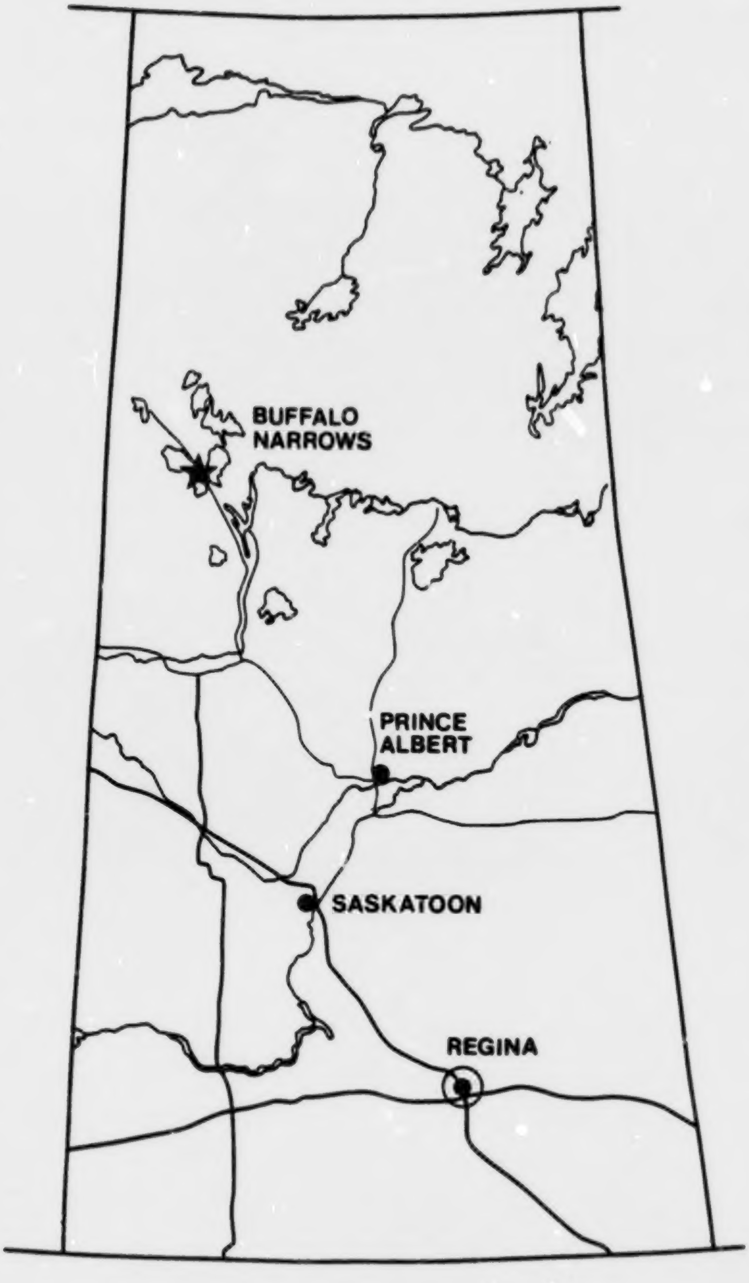
Perhaps the best way of visualizing the effect of climate on the peat mining operation is to study the annual distribution of the moisture deficiency values as they are illustrated by Figure 2-8 in the form of graphs showing the average water balance at the various locations. From the graphs, it appears that as far as water balance is concerned, the potential peat mining season in Saskatchewan varies from early May to mid-September or early October; while in eastern Canada it varies from early June to early or mid-August.

When this is considered in contrast to length of frost-free period it appears that the length of potential prime production season in Saskatchewan is restricted by the frost-free period from early June to late August. In eastern Canada the limiting factor appears to be tied to the water balance, and specifically to the period of moisture deficiency ranging from early June to mid-August. In other words, the prime production season appears to be the same at either location although the limiting factors are different. The high water deficiency values and number of bright sunshine hours in Saskatchewan give promise of a more intensive production season with associated higher production capacity than in eastern Canada.

Low precipitation values and high water deficiency in Saskatchewan indicate that drainage problems are caused to a lesser degree by climatic factors as compared to eastern Canada, where the ground is water-logged due to high soil moisture storage resulting from high precipitation. However, local topography can override the influence of favourable climatic conditions, in many areas of Saskatchewan, where the flat relief may cause drainage problems. The bog selected for the demonstration project is located at a height of land where major drainage problems are not anticipated.

.6 Recent Weather

The climatic characteristics pertinent to the demonstration site explained above are based on 30 year average data collected and calculated by the Department of Environment Canada (Atmospheric Environment). According to these averages, the climate in northern Saskatchewan appears to be suitable for peat mining. However, yearly climate or weather may occasionally temporarily preclude production. During 1979, 1980 and 1981 the climate and weather were favourable as far as potential for peat producton is concerned in the Buffalo Narrows area. However, while it is true that very rarely any substantial peat production on a fuel peat bog is obtained during the first season, in good conditions it may be attained. However, unfavourable weather conditions were encountered during 1982, the first year of bog development at the site when an attempt was made at the end of the season to produce peat. Only a small quantity was produced, not nearly enough to give a good indication of total seasonal capability. The weather factors affecting production capability during 1982 are discussed in detail in Part 4, and the parameters are compared with the standard 30 year averages described in this chapter.


BUFFALO NARROWS
PRINCE ALBERT
SASKATOON
REGINA

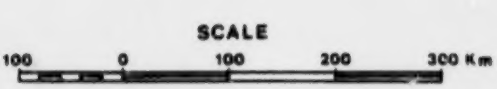

SCALE
100
0
100
200
300 Km

FIGURE 2-1

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

GENERAL LOCATION MAP

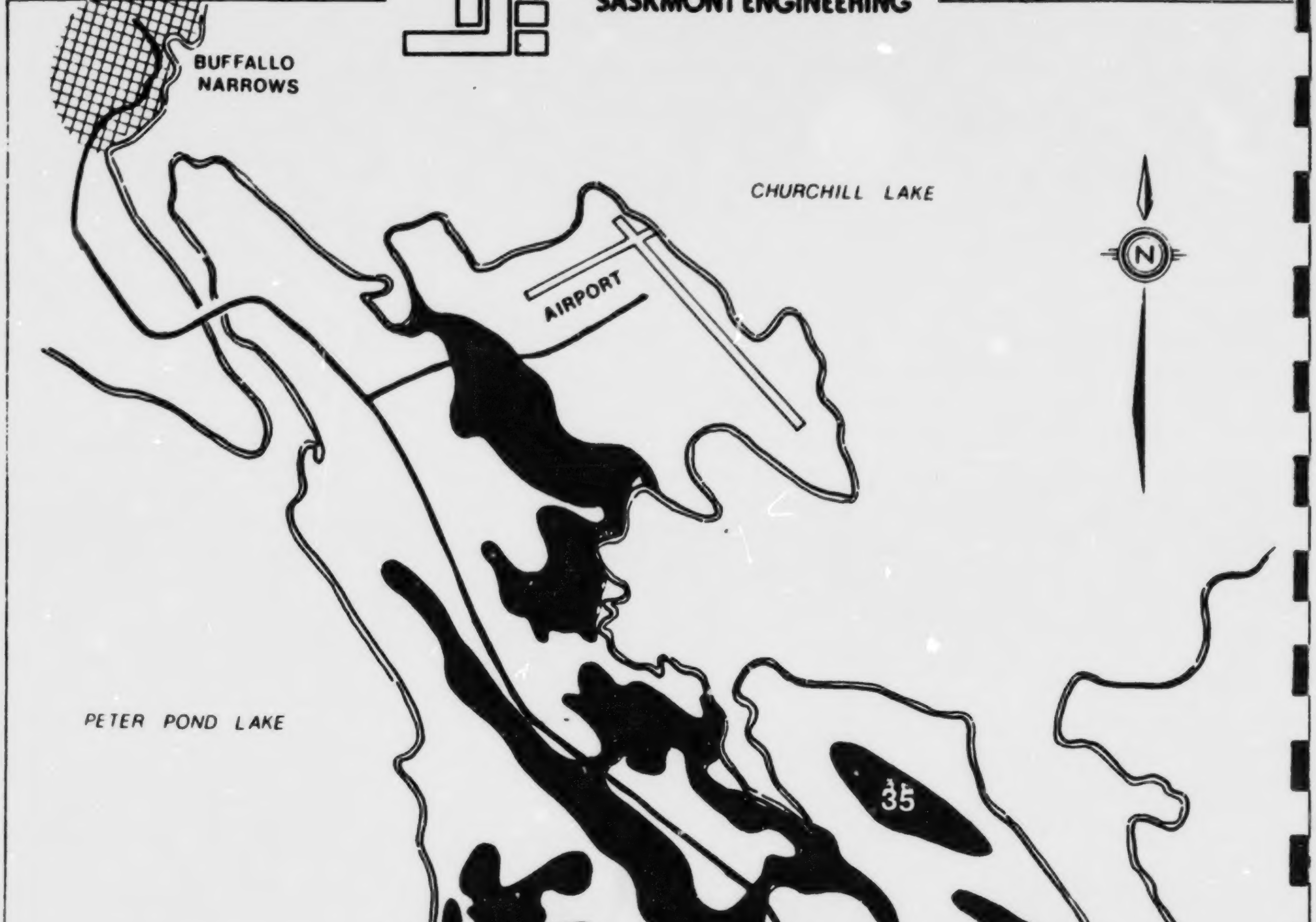

BUFFALO NARROWS
CHURCHILL LAKE
AIRPORT
N
PETER POND LAKE
35
31
SELECTED BOG
DILLON
HIGHWAY No. 155

FIGURE 2-2

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

REGIONAL DISTRIBUTION OF PEATLAND

(AND LOCATION OF DEMONSTRATION BOG)

SCALE: 1:50,000

Figure 2-3. Low altitude view of the demonstration bog before ditching.

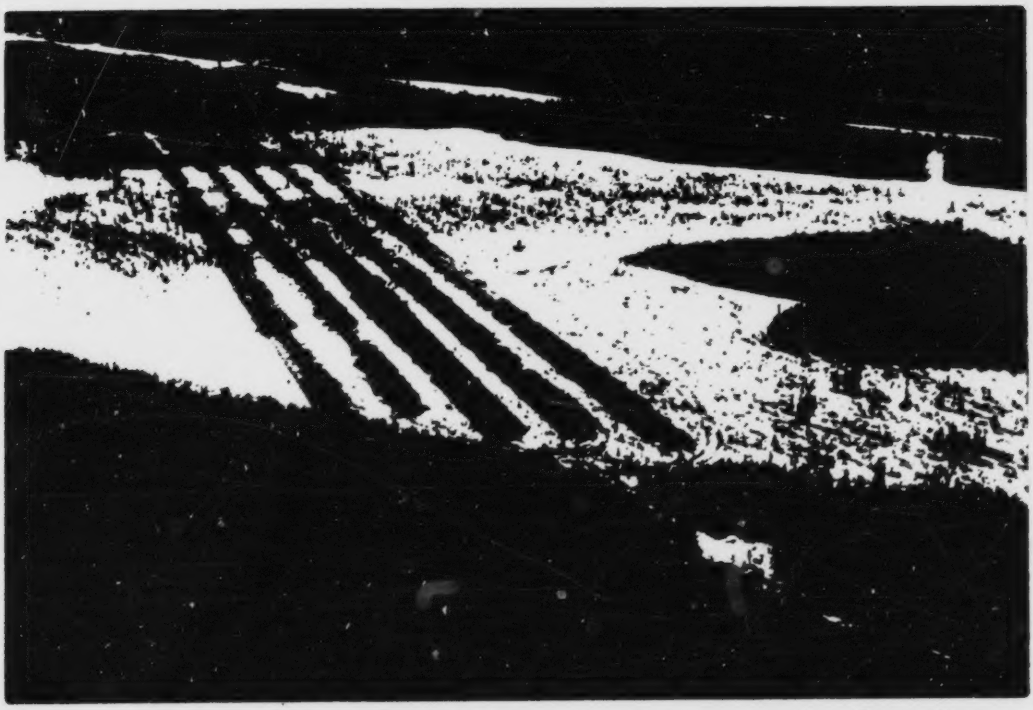


Figure 2-4. Low altitude aerial view of the demonstration bog after ditching.

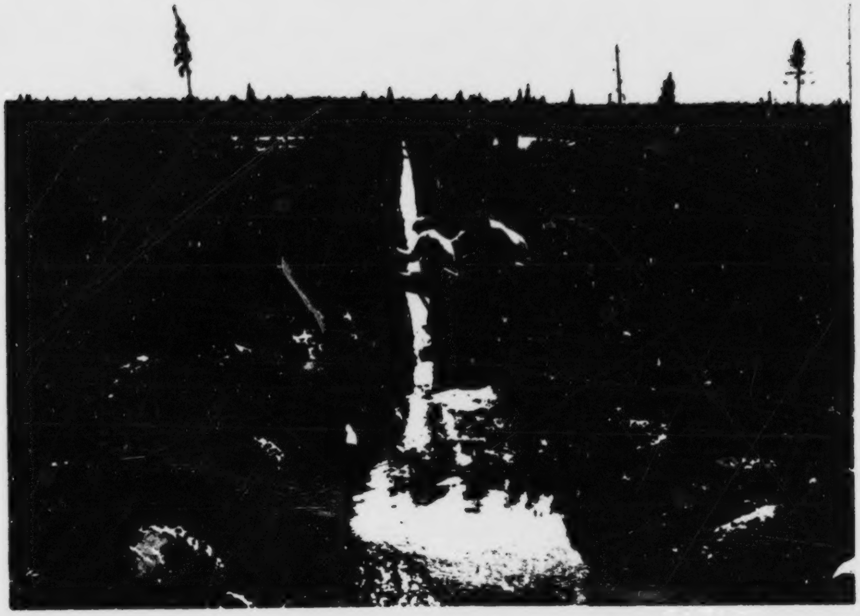


Figure 2-5 Open sedge area of the demonstration bog on the left side of the view.

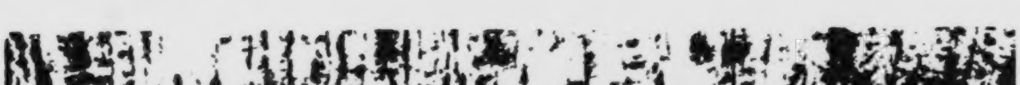


Figure 2-6 Southern treed portion of the demonstration bog.

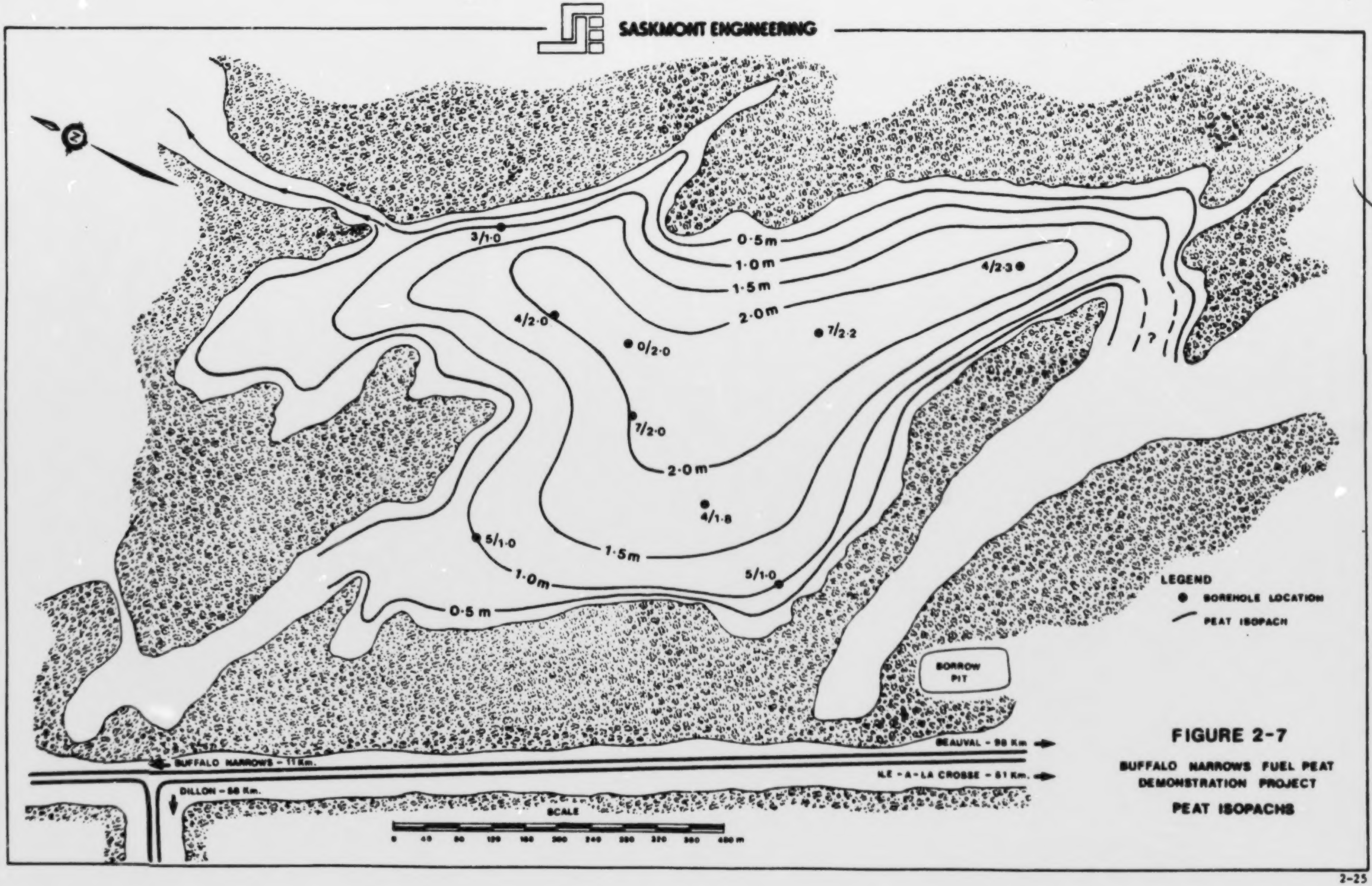

SASKMONT ENGINEERING
N
0·5m
1·0m
1·5m
2·0m
0·5 m
1·0m
1·5m
2·0m
3/1·0
4/2·0
0/2·0
7/2·0
4/1·8
5/1·0
5/1·0
7/2·2
4/2·3
?
LEGEND
BOREHOLE LOCATION
PEAT ISOPACH
BORROW PIT
BEAUVAL - 98 Km
BUFFALO NARROWS - 11 Km.
ILE - A - LA CROSSE - 51 Km.
DILLON - 58 Km.
SCALE
0 40 80 120 160 200 240 280 320 360 400 m

FIGURE 2-7

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

PEAT ISOPACHS

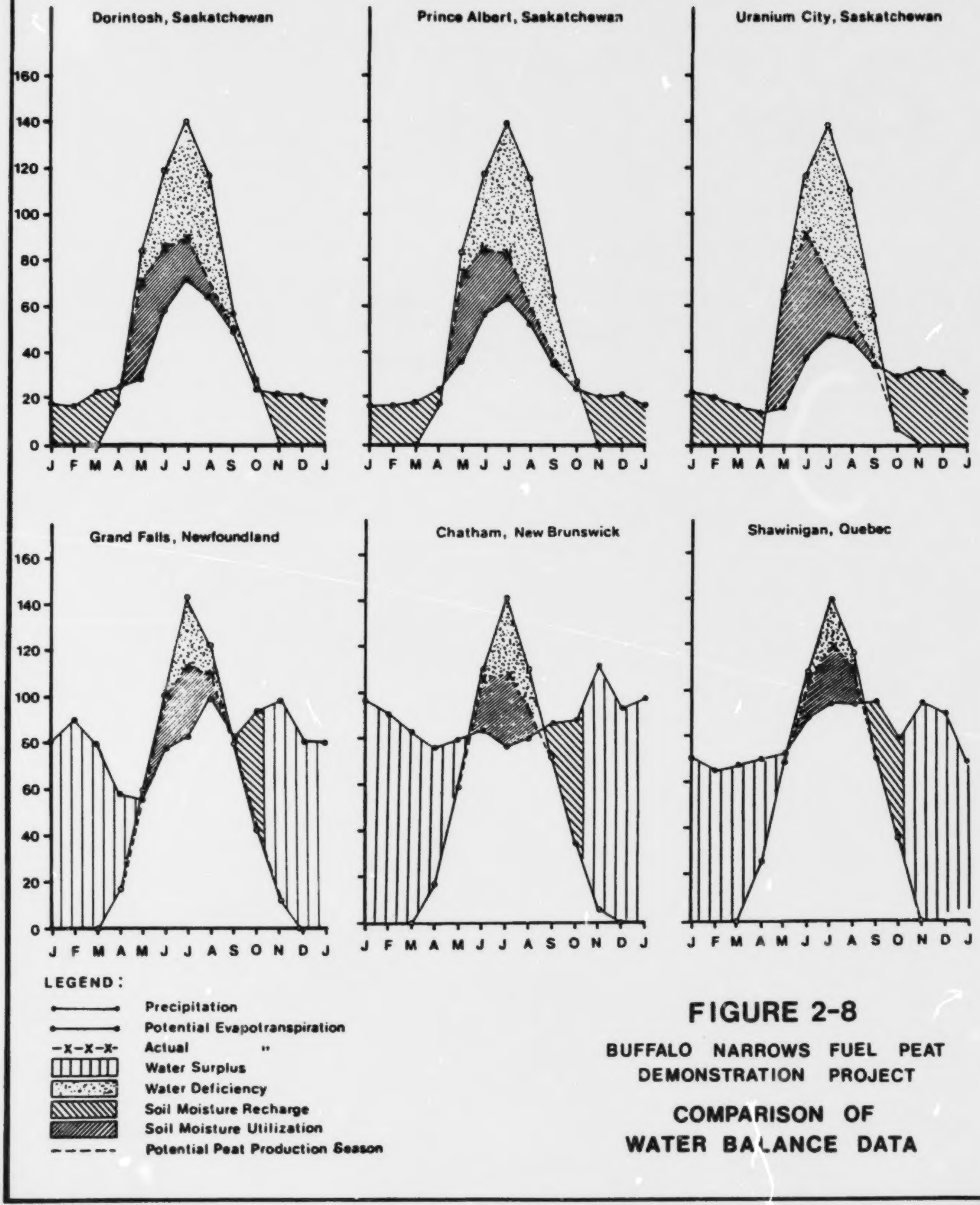


FIGURE 2-8

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

COMPARISON OF WATER BALANCE DATA

PART 3

MINE PLANNING

PART 3 - MINE PLANNING

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3.0 MINE PLANNING

3.1 MINING METHODS AND SELECTION CRITERIA

311 COMPARISON OF MINING METHODS

.1 General

The most common peat mining methods are milled and sod (bagger or extruded) methods to produce air dried peat and various wet mining methods to produce peat in a slurry form. Several of the methods are used concurrently in peat producing countries because the selection of a mining method is mainly dependent on site-specific climatic and terrain conditions. There are many variations of each of these methods, the most popular of which are discussed in the following sections.

.2 Milled Peat Mining

Milled peat mining is based on the air-drying of a fine surface layer of fluffed peat to approximately 45% moisture content before collecting it from the fields.

During bog preparation the fields are profiled in order to hasten the surface runoff of rain water during the production season. After profiling has been completed, the first operation in the production cycle is the milling of the surface layer of peat to a depth of approximately 12 to 20 millimetres. This layer is then left to dry until it has reached approximately 60-70% moisture content at the surface. This is usually accomplished within one good day of drying.

Once the top of the milled layer is air-dried to 60-70% moisture content, it is turned over by a spoon harrow to expose wetter peat to the air. It can take from one to several harrowings, and a period of half a day to two days, to lower the moisture content to approximately 45% and an extra harrowing may be required if rain intervenes during the drying process.

Once the moisture content of the loose milled peat has reduced to approximately 45%, it is collected by various methods and stockpiled for transport to the user. Peat can be collected either by large tractor-drawn vacuums and stockpiled at the ends of fields or ploughed into ridges on the centre of each field. From the ridges the peat can be transferred to storage piles, usually by either the Peco or Haku method. Both systems utilize similar pieces of equipment but transfer the peat differently to the storage piles.

Using the Peco transportation system, the field ridges are transferred laterally from field to field until all of the production is placed into a number of central storage piles, which increase in size as additional ridges are collected. The vacuumed peat on the other hand is left in smaller piles at the ends of the fields to await further transport. The central piles are sometimes covered with plastic sheets to await loading and transportation throughout the year by, e.g., a narrow gauge railway or bog trailers.

With the Haku system, peat is taken directly from the small ridges or vacuums for direct loading to tipper wagons. The peat is then stockpiled at the edge of the bog in a large central pile for transport by conventional means to a thermal power station or other user.

The basic cycles in the ridge collection method are milling, harrowing, ridging, and transporting ridges laterally to bog stockpiles (Peco) or loading ridges onto a transport to be taken to a large central stockpile (Haku).

The basic cycles in the vacuum collection method are milling, harrowing, vacuuming and unloading either to small piles at the ends of the field (Peco) or transporting directly onto a large central stockpile (Haku).

.3 Sod Peat Mining

Commercial sod peat production systems are based on producing peat sods of various shapes and drying them on the production field to approximately 35% moisture content.

A number of sod cutting machines are used. The largest ones are used in Ireland and the USSR where a Bagger excavator excavates peat along a cutting face, macerates the peat, and extrudes it through a nozzle onto a long (over 30 m) travelling conveyor which discharges the cut sods in rows onto the field to dry. Newer disc or screw sod cutters utilize smaller cutting disks (see Part 4 for an illustration) mounted on a farm tractor.

Once formed, sods are left to dry a few days and then turned and if dry enough, ridged into small ridges. Further turning may be required before collecting the sods. For collection, the sods are ridged and transported laterally onto large storage piles (Peco) or loaded directly on wagons for transport to a central stockpile for the user (Haku). The dried sods are usually delivered to the user at 35% moisture content in contrast to about 45-50% for milled peat.

.4 Wet Peat Mining

Wet peat mining methods have been used extensively in the past and currently have rather limited use, and are expanding. Wet peat mining as presently practiced commercially utilizes solar drying and only limited use of mechanical dewatering technology for unhumified peats. Considerable research activity is being done on novel peat processing methods which accept peat feedstock in a slurry form. Several of the processes are apparently ready for commercialization. Wet peat mining technology offers the advantages of extending the mining season considerably as well as some environmental and other technical advantages. In principal, a wet peat mining system follows four steps:

- excavation of raw peat by various methods from a drained or undrained bog;
- the preparation of a peat slurry (or possibly direct transport of raw peat from a drained bog);
- the pumping of the slurry to a dewatering plant; and
- mechanical or other non-solar dewatering of the slurry to an acceptable moisture content.

The problems associated with mechanically dewatering humified peat are related to the colloidal content of the material, a problem which exists in many other industrial and chemical dewatering processes. The reader is referred to a previous publication entitled "An Evaluation of Peat in Ontario", available from the Ontario Ministry of Government Services (1-800-268-7540) which includes a recent review of alternative peat dewatering techniques. Although the matter of peat dewatering has been studied and researched for many years, to date, there is not yet an operation treating fuel peat (H_4 and greater) on a continuous commercial basis; however, proponents of several processes are optimistic and in some cases are seeking financing for construction of such a proto-type plant.

312 SUITABILITY OF MINING METHODS FOR THE BUFFALO NARROWS DEOMONSTRATION PROJECT

The selection of the appropriate mining method is often governed more by the marketability of the end product than by the various technical merits of the alternative mining systems. For example, milled peat production generally offers the lowest cost per tonne, however, as a fuel, milled peat is best suited to firing in large scale boilers. Milled peat requires briquetting before it can be used for domestic heating without extensive modification of existing firing equipment.

The sod peat mining method produces fuel in a form that can be fed directly into most domestic furnaces and thus, while the unit cost may be somewhat higher than milled peat, it can be marketed directly. Also, the limitations of the market in a region may preclude the construction of a briquet plant. European briquet plants may produce 20-100,000 tonnes or more of briquets annually and, for example, a 50,000 tonne/year briquet plant may cost $10 to 20 million.

Smaller briquet plants have been proposed but would require detailed engineering investigation and market analysis to determine the actual technical and commercial viability for a northern Saskatchewan location.

The previously mentioned factors as well as others determined the final selection of a mining method for the demonstration project. In summary, the main factors considered included:

- peat source availability and access,
- quality of peat, peat type, degree of decomposition, stumps and root content,
- drainability conditions, surrounding topography and surficial geology,
- climate and weather,
- potential local market (mainly domestic),
- cost of conversions (if required) of existing firing equipment, and
- estimated mining equipment costs, demonstration project schedule and budget constraints, etc.

Based on the above considerations, the sod peat mining method was selected for the demonstration trials. As far as the climatic, bog and peat characteristics are concerned, other methods could also have been feasible.

313 MINE PLANNING CRITERIA

.1 General

The basic factors determining the mining method and the details of the mining plan are the fuel type desired (e.g. sod peat, milled peat), the climate, characteristics of the deposit available for mining (size, thickness, peat type), and the drainability of the area. In the case of dry mining methods, the most important aspect is the drainage plan, which has to accommodate not only the environment but also the mining system most suitable for the location, as well as the desired peat product. The mining and drainage plan described below are the first preliminary plans undertaken.

Climatic conditions, desired fuel peat product, and the production schedule required determine the mining method to be used, and form the basis for final mine planning. In the Buffalo Narrows area, the initial commercial requirement for fuel peat was estimated to be about 1,200 to 2,500 tonnes of peat, at a 35% moisture content, in sod peat form. The latter was the only form of peat considered suitable for the existing multi-fuel furnaces, other than briquets which were considered to be too expensive to produce particularly for the funding available for the demonstration project. Due to the small quantities of peat, and the low moisture content required, a dry mining method was considered most appropriate.

Sod peat mining was selected, not only because of the constraints imposed by the existing domestic furnaces, but also because of climate. While the mean values for various significant climatic factors indicated that the Buffalo Narrows - Ile-a-la-Crosse region was suitable for commercial fuel peat production, the day-to-day weather information was lacking. Consequently, unknown factors such as the frequency of light rain during the production season made it initially more reasonable to plan a sod peat operation.

While milled peat production is generally more efficient than sod peat production, it can be more adversely affected by chance rainfalls over short intervals. Sod peat, on the other hand, becomes hydrophobic even in after a few hours time and thus less susceptible to re-wetting during showers. This is due to the chemical changes which take place on the surface of well humified, partially colloidal peat sods during drying. This creates a "skin" with water repelling characteristics. At the same time, the sods continue drying from within and will do so even when exposed to intermittent rain, allowing the production of fuel peat with a moisture content of only 30-40% within 6-10 days, in conditions where milled peat production might be precarious.

In addition to the above, other aspects of mine planning included:

.2 Peat Thickness

The basic outline of the area to be mined was determined by the thickness of the deposit. It is common practice to avoid mining areas of the deposit less than one meter in thickness. The main reasons are the possibility of interference of the uneven mineral soil base with the mining equipment, the increase in ash content or a chance of mineral soil contamination in the shallow basal peats, and unsuitability of thin young peat layers for fuel purposes because often the layers have a low degree of humification and large quantities of roots and other woody material present.

In the case of the milled peat methods, it is possible to mine deposits less than one meter in thickness if the peat is suitable, since the milling equipment removes only about 1-2 cm layers of peat. However, when using sod cutting equipment, it is advisable to avoid thin deposits since some sod cutters can penetrate up to 80 cm into the peat, when fully extended. Thus, the risk of damage by encountering occasional boulders or rock subcrops hidden in the basal peat is greatly increased with a shallow deposit.

The drainage plan, however, is not limited by the thickness of the peat. It may cover a considerably larger area than the mining area if required for proper drainage. In the case of the Buffalo Narrows demonstration bog the drainage plan covered only 4 production fields with a mineable area of about 4 ha (Figure 3-1). The extended drainage plan covers 5-6 hectares more than the total mineable area of about 24 ha (Figure 3-2). The total mineable area is contained within the one meter peat isopach.

Because the sod cutting method was selected, the mining area was restricted to areas of the deposit with 1 meter or more of peat.

.3 Peat Quality

Peat quality not only determines the suitability of a deposit for energy purposes, but also is an important aspect when a mining method is being determined. While all the factors may indicate that sod peat production is the most desirable method, it is useable only if the peat is of a type that forms suitable sods. Certain peats near the lower end on the degree of humification scale, will not form sods that are suitable for fuel purposes. In the case of the demonstration bog, the peat was of a suitable quality for producing sod peat. (see Part 2).

Mining can be done selectively on the drained area to blend different peat qualities in order to ensure a more uniform end product. In the case of the demonstation bog, the fuel peat was quite evenly distributed throughout the bog making selective mining unnecessary. Therefore, other factors such as peat thickness and drainability were more important in determining the final drainage plans and mining procedures.

.4 Drainability

Drainability is the key factor in determining whether a bog can be taken into production. In the case of dry mining methods, a bog must be drained before it can be put into production. The aim was to drain only as much of the bog as is required to stabilize the surface of the mining area, and to ensure that enough of the bog was drained outside the mining areas to form a stable base for possible storage piles, haul roads, etc.

The demostration bog is reasonably well drainable as it is located on a height of land and appears to be drainable in almost any direction. The peat in this bog is well humified and contains large quantities of sedge remnants. This type of peat is usually relatively impervious to water, in comparison with sphagnum peat. However, with an appropriate field ditch spacing (20 m, in this case), a properly excavated perimeter ditch, and allowing for an adequate amount of time for drainage, the bog should be capable of carrying standard mining equipment a few months after commencement of drainage ditching. However, peat production rarely can be started during the first year on well humified peat because it will not tolerate multiple passes by heavy equipment and usually is slow in draining because of the inherent low hydraulic conductivity.

.5 Surface Cover

Tree cover can slow down bog preparation activities. The trees should be pulled out with their roots, not cut. Pulling the roots ensures a smaller quantity of wood in the peat, enables faster ditching and screw profiling and uncomplicated operation of the sod cutting machines.

The demonstration bog has some tree cover at the southern end. Parts of the center and the northern section are open. Tree pulling is expected to make the bog surface firmer and may enable ditching to be carried out in parts of the bog even when the peat is not frozen. The degree of woodiness of the peat was not expected to be high enough to require the use of stump removing machinery.

.6 Field Layout

The above described bog features affect the production field layout, which in turn is an integral part of the drainage layout. The ditches can be spaced at varying intervals. In eastern Canada, the horticultural peat producers have commonly used 100-150 feet spacing (30-45 m). This is often adequate on well drained, raised bogs with high domed centres and highly permeable, slightly humified sphagnum peat. In Europe, the customary ditch spacing is 10-20 m. A 10 m spacing, in most cases, provides an unnecessarily dense ditch pattern. Only in areas with high precipitation, very highly humified peat, and very flat topography is it usually justified. The close ditch spacing adds to the preparation and maintenance costs, increases the loss of useable peat area and can create problems with the operation of heavy equipment. For the conditions encountered on the demonstration bog a 20 m ditch spacing was selected.

The factors determining the field layout are varied. In the case of the demonstration bog, the outline of the area with peat thickness of 1 m or more, the general shape of the bog, length of fields, the location of the highway and consequently the most suitable location of the stockpile and service facilities, determined the layout described below.

Figure 3-1 shows the drainage plan proposed for the demonstration bog. The perimeter ditch followed the mineral terrain and bog interface, preferably where the peat depth is shallow, 10-30 cm. This ensured interception of the waters flowing from the surrounding terrain, while reducing the useable peat area as little as possible. Knowledge of the gradient of the southern end of the bog is incomplete, and the direction of the perimeter ditch there is tentative.

The reconnaissance levelling traverse and preliminary airphoto examination revealed that there was a general slope of the surface towards the north. There was a distinct drop in the elevation at locations 1, 2, 3 and 4 as shown on Figure 3-1. The most favourable outlets for the perimeter drainage ditches were located at 1 and 2 (the latter also the location of a natural drainage channel). Locations 2 and 4 are to be prepared only for a commercial operation to enhance runoff and to ensure continuous drainage in case outlets become blocked.

The selection of the ditch layout as it appears in Figure 3-1 is basically controlled by the one meter peat isopach. In order to achieve sufficiently long fields within the one meter peat isopach, the ditches were laid out in two sections. This layout allowed a long road to be constructed across the bog between the sections as well as easy access to the adjacent bog to the north if possible future expansion is considered. The area within the one meter isopach is about 24 ha, which is regarded as the mineable area. About 5-6 ha of the ditch layout is outside this area. The purpose of ditching beyond the 1 meter isopach line was to ensure proper drainage and also provide a short, shallow end field for machines to turn around. The field ends were made firmer by spreading some of the mineral soil dug out of the perimeter ditch on the adjacent bog surface. The drainage plan for the entire demonstration bog consisted of a total of about 15 km of field ditches and 5 km of perimeter ditching.

In order to finalize the overall ditch layout a more detailed bog survey is required. The purpose of the survey will be to establish the peat isopach locations, the basal contours, and the threshold elevations at the outlets to enable the required perimeter and the field ditch depths to be determined. The outlets will have to be dug to sufficient depth to ensure adequate drainage to draw down the water table in the bog about 60-90 cm, considered near optimum for a peat operation.

Figure 3-1 includes a suggested mine service layout for a commercial scale operation. This consists mainly of an access road, an office/house trailer, a service building on a concrete pad for repairing equipment, storing tools and housing miscellaneous equipment as well as a fuel tank, water well and pump, telephone and power lines. A large enough area to store about 10,000 m^3 of peat sods is proposed. A road is required along the edge of the bog to the southern tip of the northern field section. The road is located partly on soil dug from the ditch, and partly on material dozed from the surrounding terrain. Initially, the bog haul road between the two planned field sections will be a bog road capable of carrying bog machinery only. Later, it can be upgraded to handle highway trucks. This all is only for a future commercial operation if it were established.

Figure 3-2 shows the actual demonstration phase layout. This plan was drawn from an enlargement of a standard 9" X 9" format aerial photograph without the benefit of accurate land surveys. It may contain minor distortion which can be corrected in the future if a need arises. The scale of this layout is 1:2000.

A total of about 1600 m of a perimeter ditches and 3000 m of field ditches were cut for the demonstation project. Only two fields were intended for production. However, 4 fields were created by cutting 5 field ditches spaced at 20 m intervals. The details of the actual work are described in Part 4.

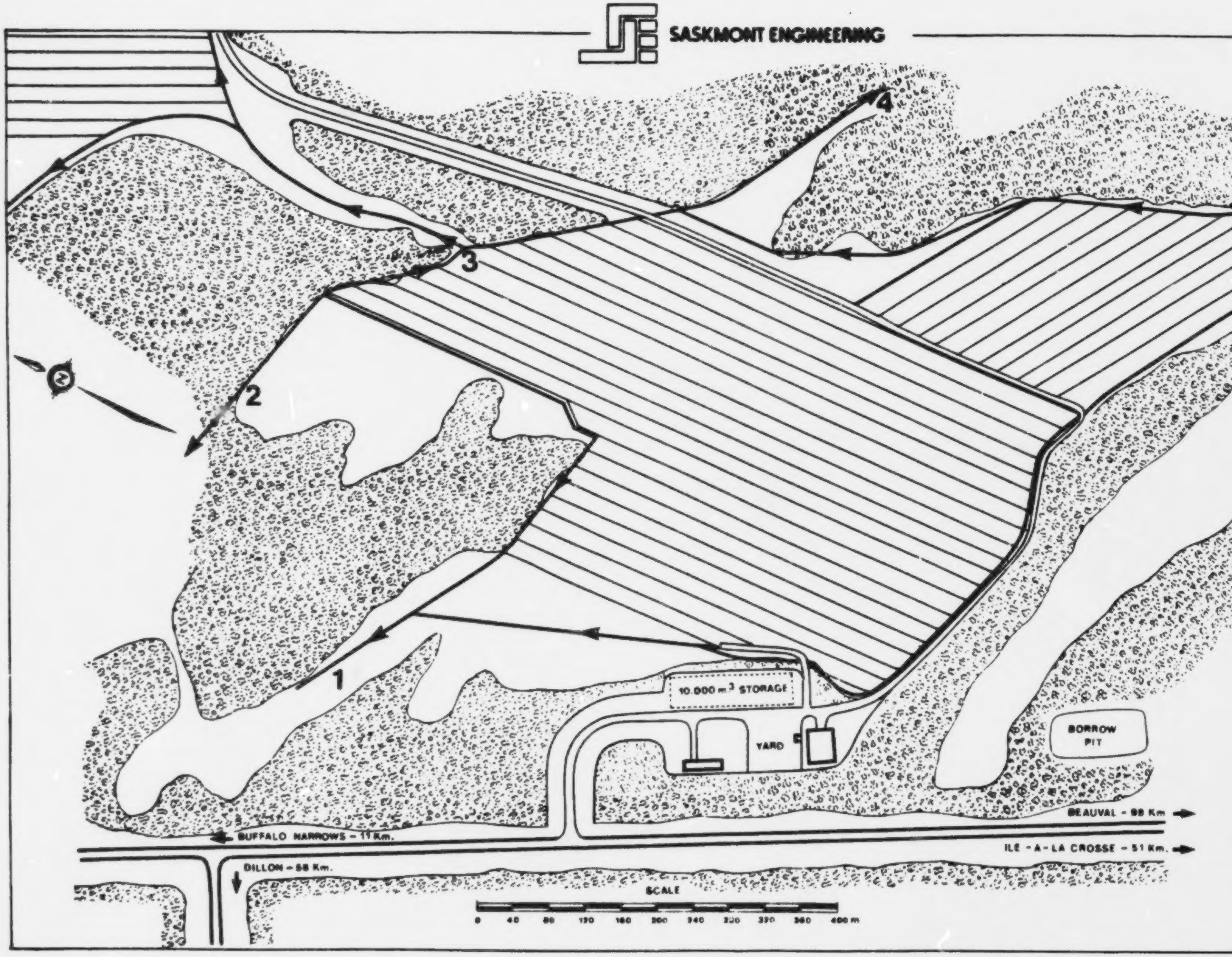
SASKMONT ENGINEERING
1
2
3
4
N
10.000 m³ STORAGE
YARD
BORROW PIT
BEAUVAL - 98 Km
BUFFALO NARROWS - 11 Km.
ILE - A - LA CROSSE - 51 Km.
DILLON - 58 Km.
SCALE
0 40 80 120 160 200 240 280 320 360 400 m
LEGEND
BOG ROAD
PERIMETER DITCH
FIELD DITCHES
2 NATURAL DRAINAGE COURSE

FIGURE 3-1

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

ORIGINAL CONCEPTUAL MINE PLAN

SASKMONT ENGINEERING

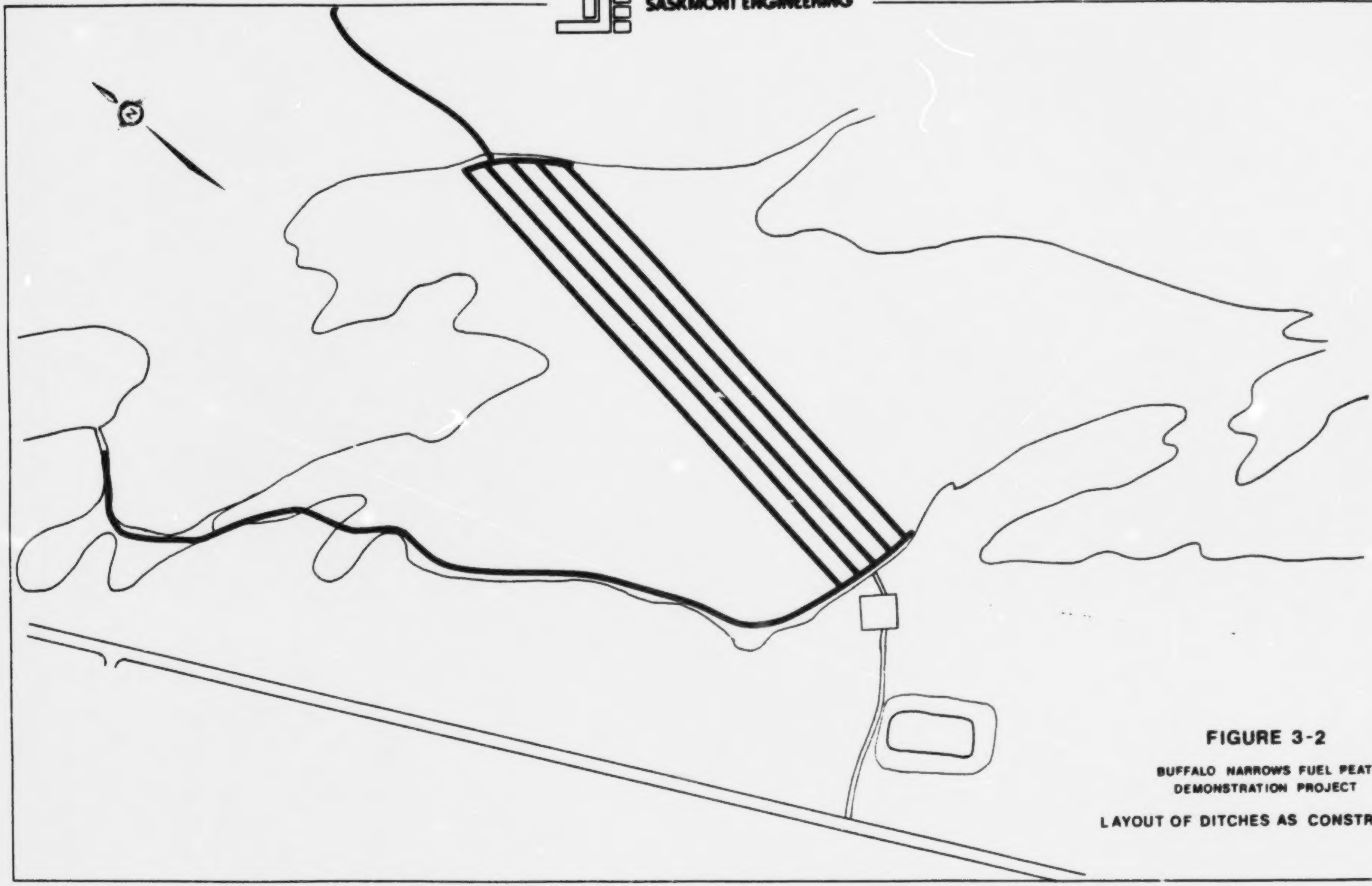

FIGURE 3-2

BUFFALO NARROWS FUEL PEAT
DEMONSTRATION PROJECT

LAYOUT OF DITCHES AS CONSTRUCTED

PART 4

BOG PREPARATION AND INITIAL PEAT PRODUCTION

PART 4 - BOG PREPARATION AND INITIAL PEAT PRODUCTION

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4.0 BOG PREPARATION AND INITIAL PEAT PRODUCTION

4.1 PRE-PRODUCTION ACTIVITIES

Peat mining can be divided into two principal phases; a pre-production phase and a production phase. Some activities carried out during the pre-production phase are repeated during the production phase (e.g. drainage work). The following is an account of both the pre-production activities on the demonstration bog as well as the first attempt to produce peat during September, 1982.

411 DRAINAGE

.1 Objectives of Drainage

The objectives in draining the demonstration bog during freeze up and with a screw ditcher with a relatively narrow cut were:

- to attain maximum ditch depth with one pass while minimizing disturbance;
- to cut a ditch with clean sides and minimize the quantity of spoil near the ditch;
- to be able to cut through frozen peat and wood;
- to avoid equipment immobilization which is a danger in unfrozen conditions;
- to promote drainage during the winter months under the snow cover in the narrow ditch, and

- to have the bog sufficiently drained by the spring of 1982 to allow pre-production preparation to commence immediately after the thaw-out and to permit an attempt at peat production later in the summer.

.2 Ditching Methods

Once the bog selection activities (surveys etc.) have been completed, usually the first step of the pre-production phase is to start the drainage of the area to be taken into production.

Generally, a perimeter ditch is dug first followed by field ditching. However, due to the unavailability of equipment, the field ditches were prepared first at the Buffalo Narrows demonstration site and the perimeter ditches a few days thereafter.

In many cases, the first step in peatland ditching is scheduled when the surface is slightly frozen. This is done largely to avoid immobilization of the equipment and the disturbance of the bog surface, while at the some time producing a clean cut ditch minimizing the amount of slumping of material into the ditch. Ditching in frozen conditions is best done in areas with a high water table where the bog surface would normally be very wet in the unfrozen state. These areas are often characterized by predominantly sedge vegetation.

On drier bogs, ditching can be done at any time if the bog is already naturally well-drained. This often is the case with domed raised bogs. These types of bogs have vegetation composed of shrubs and trees which form a strong surface mat with a high tensile strength affording the surface a good bearing capacity and enabling the use of heavy equipment, even before drainage. In these conditions the trees should be pulled off the ditch line before ditching.

Parts of the demonstration bog have a sedge cover and a high groundwater table condition which prevented ditching before freeze-up. Thus, because of the dangers of overly disturbing the surface and because of the logistics problems the immobilization of the equipment would have caused in this remote location, the ditching was done after freeze-up.

Ditching can be performed with a variety of pieces of equipment resulting in a number of different ditch shapes and sizes. Many operators prefer wide V-cut ditches while others prefer narrow ones. Usually, both types of ditches perform well, however, they do have both their advantages and disadvantages. Wide V-cut ditches remain open even initially and do not require immediate clean-up. Also during the early production phase when a bog is still soft, the open V-cut ditches tend to remain moreopen than the narrow ditches regardless of repeated travel along the ditch by heavy equipment. However, later during the production season, wind-blown peat can clog V-cut ditches quickly, causing drainage problems. Also, during the winter they may freeze up allowing little or no drainage at all.

The narrow ditches, when left undisturbed, may act as partial mole drains and allow rapid drainage under snow cover in the winter. Also, at later phase of production, they tend to remain open while wider ditches may be blocked by dust, etc. During the initial ditching of a bog with a high stump content, the narrow screw ditching machines are more effective due to their ability to cut through wood with less power than other ditchers. Screw ditchers are also very efficient in cutting frozen peat and cut the ditch more cleanly and throw the spoil further away than other ditcher types. Screw ditchers also allow the maximum depth to be reached per pass, mimimizing the disturbance of the surface caused by multiple passes of equipment.

.3 Ditching Equipment

To achieve the drainage objectives, a single Kopo ditcher, a ditching machine based on the screw-cutter principle, was selected (Figure 4-1). The machine performed well. The ditcher is outfitted with a vertically rotating screw equipped with cutting blades, and produces a ditch measuring about 0.35 m wide at the bottom and 1.0 m wide at the top with a maximum depth of about 1.3 m. The spoil that is produced is conveyed to the top of the cut by the screw and subsequently discharged on either side of the ditch by impellers attached to the upper flange of the screw.

Depending on the bog conditions, power source and whether the cut is new or re-cut, the cutting speed by this type of ditcher varies from 150 to 360 m per hour for new ditches, at a maximum cutting depth, to 600 m per hour for ditch cleaning. This ditcher was attached to a standard 3-point hitch (category II) of a farm tractor and powered through a standard 540 R.P.M. power take-off shaft (Figure 4-1).

For the power unit, a modified 67 HP Massey Ferguson 275 farm tractor with a reduction gearbox was used. This particular tractor (Figure 4-2) was modified for utilization on peatland. It was outfitting it with half-tracks and widened axles. The hydraulic system of the power unit was also changed in order to be capable of lifting a 1000 kg ditcher. The MF 275 tractor performed satisfactorily, although the reduction gearbox should have been supplied with one lower gear to allow a slower speed in areas where ice or wood was encountered in the peat layer. The slowest speed of the tractor used was 360 m/hr. Ideally, it is desirable to have gearing which allows speeds of 100 to 150 m per hour and deliver a 540 r.p.m. PTO shaft speed for the aforementioned purpose.

To avoid equipment problems, a few minor curves were made in the ditches to avoid larger stumps located directly on the ditch line. Also, some of the larger trees along the ditch line were cut to enable the ditcher to proceed with less effort. Smaller trees did not hamper the operation of either the ditching unit or the tractor (Figure 4-3).

The field ditches were cut in 2 1/2 days. The total time used was 20 hours including travel between the ditches, downtime to replace loose cutting blades and re-fuelling stops. The total length of ditches completed was 3000 meters. The general continuous ditching speed was 360 m/hr. The average speed with downtime was 150 m/hr. It is important to note that the bog started to drain immediately and that the dtiches were filled with water within an hour after being cut (Figure 4-4, 4-5, and 4-6).

Due to equipment availability problems, the perimeter ditch was not ready by the time the field ditches were finished (as shown in Figure 4-7). Nevertheless, water did drain slowly out of the field ditches due to the eastern and western ends coming in contact with the mineral sub-soil which is composed of sand and gravel. By the time the perimeter ditch was in place, ice had formed in the field ditches and was covered by snow. An inspection conducted later in the winter revealed that drainage had continued in the ditches under a snow-covered sheet of ice. The perimeter ditch was dug by a single 20-ton JSW excavator with 3-foot wide tracks. There were no access problems. The total time used to complete approximately 1600 meters of perimeter ditches was about 40 hours. Figure 4-8 shows the perimeter ditch being excavated.

The drainage objectives were attained within a short time period largely due to the peat being frozen at the time the ditches were cut, and a dry, late summer and fall and also due to the use of experienced equipment operators, a prerequisite for successful peatland operations.

.4 Inspection of Drainage Ditches

A visit to inspect the results of the initial ditching was made in early May, 1982. The ground was still frozen at the time of the visit; some ice persisted in the field ditches but the perimeter ditches were ice free. The field ditches were in good condition and for the most part clear of obstructions allowing the water to flow slowly. Some of the flow was blocked by occasional lumps of peat which had fallen into the ditch, residual ice, a few rocks and in the western end, by a shallow stretch of the perimeter ditch. Figure 4-9 shows a clean, undisturbed field ditch. In Figure 4-10, residual ice bridges can be seen. During the visit some loose peaty spoil was found on the ice bridges. The peat was not expected to pose any drainage problems because once the ice had melted it would either have been washed out by run-off or it would have been deposited on the bottom of the ditch, and in fact this happened.

The perimeter ditches performed well during the winter of 1981-1982. The perimeter ditch on the eastern side of the bog was in a relatively good condition (Figure 4-11). However, later in the season the perimeter ditch on the western side did not flow well, partly due to some collapsing of the ditch walls and also because, in a few locations, the ditch had not been cut deep enough (Figures 4-12 and 4-13). One of the reasons for the poorer performance of the perimeter ditches later was the shape of the cut. Ideally, when ditching with an excavator in peat, a specially shaped bucket is often used (Figure 4-14). However, such buckets are not readily available. The slumping could have been minimized by digging the ditch in a series of steps to ensure a wide V-cut as is shown in Figure 4-15. Figure 4-16 shows schematically what happens when the ditch is dug vertically in peat and what had happened to the demonstration project perimeter ditches. The main reason for deviating from the usual standard sequence was the urgency of getting the work done before the onset of the winter.

At the time of the inspection visit (May 1982) the bog was still partly frozen and some drainage due to the melting of ice in the peat was taking place in the drained as well as the undrained areas. The drained area was otherwise quite dry with no free water on the surface between the field ditches. The adjacent undrained areas of the bog were still saturated with and covered by free water. This indicated that the groundwater level between the ditching had receded during the winter months and that the spring melt runoff from the drained area was accelerated while outside the ditched area it still was high. Also, the absence of strong percolation of water from the sides of the field ditches indicated that the groundwater level had receded.

.5 Follow-up Ditching Activities

Initially, the drainage of the bog progressed satisfactorily. However, in the spring of 1982, during the thawing out of the frost lenses within the peat layer, some shifting at the sides were encountered both in the perimeter and field ditches. To improve the drainage, the ditches were cleaned manually, as well as with a small backhoe (perimeter ditch) (Figure 4-17). A Dondi ditcher (Figure 4-18) rented from the Carrot River Peat Company was used to re-cut the field ditches.

Further field ditch cleaning was done after the first sod production cycle. At that time, a thorough levelling pass of all the ditches was performed. This is discussed later in the sections on the production phase and the future work recommendations.

412 ACCESS, STORAGE AREA AND BRIDGE CONSTRUCTION

For access, a road was constructed to link the main yard to the highway. A pair of culverts were placed in the ditch and covered (Figure 4-19). Elsewhere, low areas were filled in. Later, the entire access road was gravelled (Figure 4-20).

A small tracked loader (John Deere 450) was used to prepare the storage area/main yard. (Figure 4-21) Upon completion, this area too, was gravelled (Figure 4-22).

Prior to removing the tree cover from the two fields, two bridges were constructed, one linking the yard and Field 2 (Figure 4-23), the other joining Fields 2 and 3 (Figure 4-24). The bridges were made from poplar planks nailed to discarded telephone poles.

413 TREE REMOVAL

.1 Surface Vegetation

The surface vegetation found on both fields ranged from a thick surface layer of sphagnum moss and sedges to black spruce trees 4 to 5 m in height. On both fields large treeless areas were found as well as dense stands of black spruce (Picea mariana), and also some transitional areas. In the treeless areas, referred to as "open" (Figure 4-25), a thick layer of Sphagnum moss and several Carex species covered the deposit as well as some Eriophorum virginicum and Kalmia polifolia. Some very short trees were also found in these areas. Other areas had an EI cover (Radforth Cover Classification, 1952). In the areas labelled EI, the E principally indicated the presence of black spruce trees 0.5 to 1.5 m tall with a understory of Sphagnum moss, Carex species, Eriophorum virginicum, and Kalmia polifolia. Finally, in the areas of BEI cover, tall (4-5 m) trees of the same type were found as well as the usual surface layer of Sphagnum, Carex, Eriophorum and Kalmia polifolia (Figure 4-26).

.2 Tree Pulling Equipment

A single 70 HP Ford 6600, 4-wheel drive tractor was used for pulling the trees (Figures 4-27). The tractor was equipped with dual tires, a 3-point hitch and a front-mounted bucket for loading.

To pull the trees, two 3/8" X 10' chains secured to a clevis attached to the drawbar were used (Figure 4-28).

Diesel fuel consumption data for the 70 HP tractor is summarized in Table 4-1. It appears that the tractor operated efficiently, consuming only 2.2 L/hr on average. However, it should be noted that during this operation the tractor for the most part was only being operated at 1200 r.p.m. instead of at 1900-2100 r.p.m. A listing of the causes of downtimes can be found in Table 4-2. The percent downtime for this operation was 18%.

TABLE 4-1

Fuel Consumption During Tree-Pulling Operation

(70 HP Ford 6600 tractor; operated primarily at 1200 rpm)

Hours Used	Fuel (1) Consumed	Hourly Consumption Rate (L/hr)
21	45.9	2.2
12	24	2.0
10	24	2.4
11	23	2.1
		Average: 2.2 L/hr

TABLE 4-2

Downtime - 70 HP Ford 6600 Tractor

Date	Hours	Reason
11/6	2.0	Fill outside duals with air
18/6 / 19/6	5.0	Replace inside left front tire; straighten out bent plates.
21/6 / 22/6	2.5	Replace a mangled copper hydraulic line.
23/6	3.0	Replace missing nut and sheared bolt off of the left front dual linkage.
TOTAL	12.5 Hrs.	

Total time scheduled for tree-pulling operations: 68 hrs.

Total hours - downtime: 12.5 hrs.

∴ % Downtime $\frac{12.5 \text{ hrs}}{68 \text{ hrs.}} \times 100\% = 18\%$

TABLE 4-3

AREA OF SURFACE VEGETATION CLEARED

DATE	AREA OF SURFACE VEGETATION CLEARED BY TYPE (m^2)			HOURS WORKED ON CLEARING	TOTAL
	OPEN	EI	BEI		
12/6	600	400	600	6	$1600m^2$;0.16 ha
13/6	-	-	3,000	8	$3000m^2$;0.30 ha
16/6	1,200	-	1,000	4	$2200m^2$;0.22 ha
17/6	1,300	-	1,200	6	$2500m^2$;0.25 ha
18/6	500	2,200	-	4	$2700m^2$;0.27 ha
18/6	700	-	600	2	$1300m^2$;0.13 ha
21/6	2,200	400	900	7 1/2	$3500m^2$;0.35 ha
22/6	800	300	1,100	6	$2200m^2$;0.22 ha
23/6	-	-	1,600	5	$1600m^2$;0.16 ha
24/6	1,100	1,500	800	7	$3400m^2$;0.34 ha

Total: 2.4 ha

.3 Area Cleared

The area of the two fields cleared for sod peat production was 2.4 ha. The number of hectares cleared each day is summarized in Table 4-3. In reviewing Table 4-3, it is noted that it was possible, in one 8 hour period, to clear 3000 m^2 or 0.30 ha of dense BEI cover using a single tractor and 3 men (including the operator). It took nearly 55 hours to clear both fields.

.4 Problems Encountered

During tree pulling operations, some difficulties were incurred. Frost lenses still present in the peat layer were beneficial in their capacity to enhance the bearing capacity of the fields, however, they were also detrimental at times when it came to pulling out a tree and all of its roots. At best, only 2/3 of the root system could be dislodged if the roots were locked within the layer of ice. As a result, a second thorough search of the fields for stumps and roots was necessary.

.5 Tree Removal Off Bog

Following the tree pulling, the trees were hauled off the fields. A wagon was constructed for this purpose. Its dimensions were: 4 m long, 2.5 m wide and 1 m high (walls), (See Figure 4-29). When hauling the trees off of the bog, the rear and right walls were removed to ease loading and unloading.

Field 2 was cleared in two stages. Initially, the field was cleared of all loose and dislodged trees; this took approximately 10 hours, followed by 12 hours of pulling roots (primarily those which had not been dislodged earlier due to the frost lenses). Subsequently, an additional 4 hours were spent collecting the pulled roots. Field 3 was cleared all in a single pass,but since it had more tree cover, the removal toook longer; altogether 26 hours.

During this phase of the operation, there were no mechanical breakdowns, although there was some downtime associated with general machinery maintenance as shown in Table 4-2. Fuel consumption rates were similar to those (2.2 L/hr.) during the tree pulling phase. The main difficulties incurred stemmed from a softening of the fields due to the thawing of the frost lenses. As a result, a series of deep ruts began to appear in the heavily travelled areas. To correct this problem, the liquid in the tractor tires was drained to reduce the weight.

414 BRUSH CUTTING

In order to prepare the surfaces of both fields for rotovating, a Ford 939 rotary cutter was used to cut light surface vegetation still remaining and also to minimize the entanglement of small roots and shrubs in the rotovator (Figure 4-30). For the size of the task, the rotary cutter was adequate, however, if a larger operation were undertaken, a larger unit would be required.

The operation was completed in two 8 hour shifts giving an average performance of 1.2 ha/day. This included the time spent in locating shear pins and transporting the mower to the site from Buffalo Narrows.

415 ROTOVATING

A Maschio rotovator (175 cm cutting width) was used to chop and loosen the top 20-25 cm layer of peat (Figure 4-31).The purpose of the tilling was to hasten the drying of the surface layer and to allow easier passage by the screw profiler for subsequent removal of the surface layer.

Rotovation of the two field surfaces took two 8 hour shifts, or a rate of about 1.2 ha/day. The rotovator used was more than adequate for the demonstration project, however, for a large commercial operation larger rotovators would be required.

416 SCREW PROFILING

Once the fields dried sufficiently after the rainfalls in August, profiling the surfaces of the fields began in early September. A Degelman screw profiler rented from the Carrot River Peat Moss Company was used for this activity (see Figure 4-32). The normal profiling procedure was modified to attempt to obtain some sod peat production during 1982. Usually the fields are profiled so that a camber is produced resulting in a raised centre which facilitates surface runoff during precipitation events. Usually, when the production fields are profiled, the unhumified surface layer is augered by the screw profiler towards the centre of the field. From there it is removed to a suitable location by wagons loaded either by tractors equipped with buckets or by a collector/conveyor system. This approach requires a number of expensive pieces of equipment.

Due to budget constraints, and in an attempt to produce some sod peat before the end of the production season, it was decided that the unhumified surface peat would not be completely removed from the production fields. Instead, it was augered to one side of each field using the screw profiler. By placing the surface peat to one side of the field (without removal), approximately half of the field was available for sod peat production directly. The reason for removing the less humified peat from the surface was to enable the sod cutter to reach humified peat and to produce coherent sods. The unhumified surface peat does not sod and also tends to clog the sod cutter.

The equivalent of seven full working days were required to profile Field No. 2 to the point where approximately 30 cm of the surface layer was removed from half of the field. Field No. 3 required the equivalent of 5 1/2 days of profiling. Due to the high precipitation and the lateness of the season, Field No. 3 screw profiling was not done as thoroughly as Field No. 2. However, enough surface material was removed from Field No. 3 to allow sod cutting in the future. On average it took 18 minutes to make one working pass of the field and 6 minutes for the unworked return trip. A complete cycle took 24 minutes, and generally 7 complete cycles were made over a 3 hour period.

During the profiling operation, the fuel consumption of the tractor was approximately 7 L/hr., a considerable increase in fuel consumption in comparison with the tree-pulling operation. During the tree-pulling operation, the tractor was operated in second gear (at 1200 engine rpm) whereas during screw profiling, it operated in the lowest gear (at 1900 engine rpm) in order to deliver a PTO shaft speed of 540 rpm.

The Degelman screw profiler was not well-suited to this type of work for which a profiler especially designed for peat is noramlly used. The absence of a semi-circular shroud plate to partly enclose the auger, restricted the capacity of the profiler to convey peat, and consequently, additional passes were required. The lack of hydraulic cylinders at the ends of the auger also did not allow control of the horizontal profile angle and made it difficult to achieve a lateral gradient for the field.

4.2 INITIAL PEAT PRODUCTION

421 INTRODUCTION

A small volume of peat was harvested and placed in dry inside storage to effect further drying. The volume of peat harvested was considered sufficient to enable testing of local peat in the home-heating phase of the demonstration project.

422 EQUIPMENT

A Suokone Oy Meri PK-1A sod peat machine capable of cutting to a depth of 370 mm was used to produce the sods (Figure 4-33). The machine was mounted on the 3-point hitch of the Ford tractor. The power requirement of 70 KW was delivered through a PTO shaft rotating at 540 r.p.m. To deliver the necessary torque to the sod peat machine, the tractor was operated at 1900 r.p.m. in low range and in first gear. Running at 1900 r.p.m., the tractor consumed on average 7 L/hr. of fuel.

The sods were collected manually and placed in containers ranging in size from 100 to 150L. Once filled the containers were loaded on to a wagon and taken to the storage area. The sods were then transferred onto a 1-ton truck and transported to the Department of Northern Saskatchewan (DNS) supply depot for storage and additional drying.

423 PEAT PRODUCTION

Although 13 sod cutting passes were made on Field No. 2, none covered the entire length of the field due to wet conditions. Ten of the passes were about 500 m long while the remaining 3 were approximately 400 m. Localized wet spots near the centre and at the ends of the field resulted in 3 of the passes being shortened to avoid immobilizing the machinery and also to minimize serious disruption of the field. In total, approximately 42 m^3 (extruded volume) of peat were cut.

Besides wet field conditions, sod peat production was hampered by the weather. The basic problem faced during the late summer in the Buffalo Narrows area is the shortness of the drying period during the daytime. Although the weather was warm and sunny almost daily, the temperature dropped below freezing every night. Consequently, the peat sods were frozen on the surface and remained in that state practically until noon of the following day. With the days getting shorter, the actual number of hours of sunshine available to dry the thawed peat sods was greatly reduced. At best, there were between 4 and 5 hours of drying weather daily. Also evening and morning dew and fog reduced the drying. Windy conditions helped to dry the sods to an extent, however, the required 35% moisture content was not achieved.

In addition to the unfavourable weather conditions for drying, wet field conditions also hampered the drying of the sods. Due to the softness of the bog surface, sods collected in the ruts left by the tractor tires (Figure 4-34). As a result the air movement in and around the sods was restricted, resulting in slower drying. Also, rain collected in the ruts and rewetted the partially dried sods from time to time.

Although the summer was generally unfavourable, and peat production was attempted quite late in the season, the results were encouraging considering that some peat was produced during the first season, immediately after the initial drainage. Generally, peat production can only be started after 2-3 years after intitial drainage. The fact that some peat was produced during the first summer gives a very strong indication that it is feasible to produce sod peat in northern Saskatchewan as far as the technical aspects are

are concerned. The peat production cost calculations, (See Part 6), are inconclusive since a full production cycle was not attempted in 1983 due to a major cut in the demonstration.

The test did show that the common peat types as found at the Buffalo Narrows site sod well even at a low degree of humification. Figure 4-35 shows a close up of the sods. The peat encountered at the demonstration site was sedge-sphagnum or sphagnum-sedge peat with a degree of humification at the surface of about H4-5, and at a depth of 0.3-0.5 m, H7. Most of the moss peat surface cover was removed by surface profiling to allow the sod cutter to reach the more humified peats.

424 PEAT COLLECTION AND STORAGE

When it became apparent that the September weather would not afford a proper drying of the sods, about 42 m^3 of loose sods or the equivalent of about 8 tonnes at 35% moisture content) were manually collected from the bog. The peat was stored at the DNS Depot where the drying of the sods was enhanced by fans and occasional turning.

In a commercial operation, sod collection is carried out by ridging and loading the dried sods mechanically onto a bog wagon for transport to the edge of the bog. Since manual collection of the sods does not reflect the method normally utilized, the costs of the collection phase cannot be used for any operational cost estimates. Figures 4-36 and 4-37 show various stages in the sod collection process. The hay wagon used for transporting the sods from the bog was not suitable for bog work. It was too lightly constructed and its wheels were too small. For a commercial operation a proper bog wagon as shown in Figure 4-38 should be used.

425 POST PRODUCTION DRAINAGE

The repeated passes by bog preparation and production equipment tended to push unharvested peat towards the drainage ditches. This caused the ditches to be partially filled by peat from the sides of the ditches and partly by peat upswelling from underneath. To correct this situation and to ensure proper bog drainage for the future, a thorough survey of the bog surface along the ditches and the ditch inverts was carried out after the first attempt to produce peat. The survey was also done also to facilitate the planning for the follow-up drainage activities required for peat production originally scheduled for the 1983 field season. Figures 4-39, 4-40, 4-41 and 4-42 show the survey results. The recommended depth of each ditch has been provided on the profiles. In October, 1982, the field ditches were deepened to the recommended depth using a Dondi-ditcher. The perimeter ditches were left as shown in the profiles due to budgetary constraints.

In order to keep the bog in a well-drained condition, the perimeter ditch should be deepened to the line indicated. However, if the bog is abandoned and left to revert to its former state, this can be achieved by merely blocking the drainage channels.

Figure 4-43 shows the shape of the prepared fields after the surficial peat had been pushed by the screw profiler to one side of Fields No. 2 and 3 to enable the sod cutter to reach the more humified peat. Fields No.1 and 4 were left unprepared and acted as buffer zones. The vertical scale is (1:50) exaggerated 8 times in relation to the horizontal scale (1:400) to give a better indication of the elevation differences.

426 PEAT PRODUCTION AND WEATHER

Usually when a bog is taken into production it takes 2-4 years from initial drainage before efficient production can be started. It is sometimes possible to produce some slightly humified sphagnum peat from a raised bog under favourable drainage and climatic conditions shortly after the drainage system is in place. However, this was not the case at the demonstration bog which contains considerable quantities of well humified sedge peats which do not drain as well as sphagnum peats. However, this site was ready for final screw profiling and a late season attempt at peat production was made.

.1 Climatic Analysis of the 1982 Production Season

With the exception of the month of August, the day-to-day weather conditions from the beginning of June to the end of July were quite suitable for peatland preparation and peat production activities.

As shown in Table 4-4 the mean monthly temperature in 1982 for each month of the production season except August was very close to or exceeded the 3-year average (mean monthly temperature data for Buffalo Narrows is available only from November, 1979 to the present) of the mean monthly temperature (See Table 4-4).

TABLE 4-4. Mean Monthly Temperature Comparison

MONTH	MEAN MONTHLY TEMP.(°C)(1982)	3-YEAR AVERAGE MEAN * MONTHLY-TEMPERATURE (°C) (1980-1982)	DEPARTURE FROM 3-YR. AVERAGE	
			(°C)	(%)
JUNE	14.6	14.6	0	0
JULY	17.3	17.7	-0.4	2%
AUG.	13.5	15.8	-2.3	15%
SEPT.	10.4	10.1	+0.3	3%

*Based on 3 years of available information.

July and September departed from the average by 2 and 3% respectively, nevertheless, their departure was not as pronounced as the 15% recorded for August. Environment Canada - Atmospheric Environment Service'sseasonal map of "Departure of Mean Temperature from the 1951-1980 Normal" for August 1982 see Figure 4-44) indicates the extent of this anomalous condition. Besides being cooler, the month of August was also wetter than usual. As Table 4-5 indicates, the Buffalo Narrows region received 24% more rainfall in August than usual.

In fact, August, 1982 was the fourth wettest August on record since 1968. This departure from the mean is also illustrated in Environment Canada - Atmospheric Environment Service's "Total Precipitation - Percentage of 1951 - 1980 Normal", seasonal map for August (see Figure 4-45). According to the map, Buffalo Narrows lies in an area which received between 100 to 150% of the 1951-1980 normal total monthly precipitation normal.

TABLE 4-5. Monthly Total Precipitation Comparison

MONTH	TOTAL PRECIPITATION 1982 (mm)	TOTAL PRECIPITATION Mean (mm)*	DEPARTURE (mm)	FROM MEAN %
June	43.8	65.1	-21.3	33%
July	64.2	71.5	- 7.3	10%
August	88.4	71.5	+16.9	24%
Sept.	19.4	58.4	-39	67%

*Based on 15 years information (1968-1982)

Late in July, the field ditches were re-cut and the two production fields rotovated. At that time it was planned that the bog would be left to dry for about two weeks before attempting screw-profiling to be followed later in August by sod cutting. Unfortunately, in the beginning of August several heavy precipitation events (the weather station at Buffalo Narrows airport recorded

42.8 mm of rainfall in the first six days) resulted in softened field conditions. Following this, no sustained periods of precipitation-free days occurred; the longest precipitation-free period was 5 days in August. By the time field conditions improved, it was early September and the days became short and the night cool. This did not allow the sods to dry properly on the fields, and consequently, they were collected manually and transported to the DNS Depot for final drying.

In case of dry mining the climate is one of the most important parameters affecting the efficiency of the operation. It takes about 10-12 days to dry sods on the field to the required 35% moisture content in the climatic conditions that prevail in the Buffalo Narrows area. The climate on the other hand is comprised of weather. The climatic conditions may be favourable for peat mining but, the day-to-day weather conditions may still preclude dry mining. Dry mining requires a number of consecutive dry days, suitable wind and relative humidity conditions and no overnight frost or dew. During the September 1982 production attempt the weather had already turned humid and cool and not suitable for a commercial peat production activity. However, earlier during the summer, while the pre-production activities were being carried out, the weather was favourable for peat production, confirming the climatic suitability of this area for peat production.

427 DISCUSSION OF RESULTS

The primary objectives of the 1982 field program were to clear the surface vegetation from the two production fields, prepare the surface for peat production by rotovating and screw profiling and ensure that the area was drained properly, and if possible, produce peat sods for the domestic heating trials scheduled for the winter 1982/83. The drainability of the peat, climatic and local weather conditions were recognized as potential hazards towards achieving all of the project objectives during the 1982 field season and it was anticipated that full peat production cycles would only be achieved in the following year. Unfortunately, the budget support for the program was withdrawn prior to commencement of the 1983 field season.

The fuel peat demonstration project as originally planned for Buffalo Narrows was modest in design due to budgetary constraints. A main project objective was to determine the suitability of the peatlands, peat type, climate and weather in the area for the production of fuel peat. Compromises on equipment, as opposed to a commercial fuel peat operation, were required due to cost, the availability of certain equipment from other operations in Saskatchewan, and the fact that the equipment would be required for a short period. For instance, a screw profiler was available to the project from the Carrot River operations of Saskatchewan Minerals Corporation at considerable less cost than the larger, European model manufactured specifically for peatland preparation. The Carrot River machine was a Canadian-built agricultural screw profiler and took more time in removing the relatively thick peat layer than anticipated. Matching the various equipment pieces of the non-standard fuel peat production set required numerous field modifications, considerable ingenuity, time and effort and also frequent disruptions to the work pattern. The use of a complete set of standard fuel peat production equipment would have been preferable but, was precluded on the basis of cost.

During late summer 1982 it became apparent that sod peat production would be difficult to achieve during the 1982 field season. Combined with budget uncertainties for the following 1983 field season, it was decided to accelerate the peat production attempt by profiling the surface peat onto the one side of each field (to avoid haulage off the field) to make available approximately half of each field for sod production. Some minor success was achieved and late in September approximately 8 tonnes of sod were recovered manually, albeit not at the usual moisture content of 35%. The sods were removed as soon as they could withstand transport. The production run as attempted did demonstrate sod production is physically feasible in the Buffalo Narrows area, nevertheless, many questions regarding potential yields per hectare, drying rates and costs were left unanswered. With the required modifications to the project to produce peat in the following 1983 field season, the technical and economic questions could have expected to have been answered. Unfortunately, this was not possible.

428 COMMERCIAL PEAT PRODUCTION

The Buffalo Narrows Fuel Peat Demonstration planned as a pilot peat production and utilization test, and was not an attempt at a commercial scale peat operation. The information included in this sub-section is additional information to the reader to indicate the approximate investment required and an exact sequence of events anticipated during a typical peat production cycle.

Table 4-6 shows the capital investment and list of equipment required to operate a 100 ha peat production site, considered more or less the minimum area required for a commercial operation. The equipment fleet as shown can produce and stockpile peat at a bogside storage location.

Some of the pieces of equipment shown in Table 4-6 can handle more than 100 ha in a year and in case a large area were under production savings in the capital layout in regards to equipment would be realized. Approximately $700,000 of equipment is required not including operating costs.

A typical production cycle at the commencement of a production season, on a prepared field would commonly include:

1. Ensuring that the fields are smooth and properly contoured after the winter. If not, they would be screw profiled and/or levelled (levelling blade).

2. Cleaning the ditches with a rotary ditcher and/or backhoe, depending on the type of ditch (field ditch, perimeter ditch) and the conditions on the bog.

3. A cycle of sod production covering each field with sods.

TABLE 4-6

Full-Scale Equipment Fleet for Commercial Sod Peat Production

Item	Size	No. Required for 100 ha Area	Prices (Late 1983)
Ditcher		1	28,000
Screw profiler	5.7 m	1	28,500
Levelling blade	5 m	1	11,000
Excavator		1	185,000
Excavator bucket	1000 litre	1	3,000
Sod cutter		3	21,000
Sod turner		1	11,500
Sod ridger		1	11,000
Sod loader		1	37,700
Sod shaker screen		1	26,000
Bog trailer	15 m^3	3	13,000
Tractors	100 HP, 4 W-D	4	47,000
	120 HP' 4 W-D	1	55,000

Total fleet price: $686,700.

Miscellaneous items included brings the total to about $700,000.

Prices FOB supplier in Montreal.

4. After a period of 3-6 days depending on the drying conditions, the sods would be turned to achieve a moisture level where they can be handled. Sod turning is carried out by a plough that goes partly under the sods and tumbles them, or by a pick-up system similar to that shown in Figure 4-46, which is used to load the sods. The difference in the sod turner compared to the loader is that instead of throwing the sods picked up into a container,it lets them again tumble behind the machine.

5. Depending on the drying conditions, the sods are ready for pick-up in 10-16 days. The pick-up is carried out by, e.g., a piece of equipment as shown in Figures 4-46 and 4-47. The sods are picked up by a horizontal revolving drum and thrown by a revolving drum into the trailer towed by the same tractor. The sod collection systems use a scoop and conveyor belt to load the sods onto a trailer towed by another tractor.

6. After sod collection, the field is smoothed by a screw-profiler or a levelling blade to commence a new cycle. On aproperly prepared bog, and depending on the bulk density of peat, 100-200 tonnes of sod peat (35% moisture content) per hactare per year can be produced.

Figure 4-1. Kopo screw - type ditcher.

Figure 4-2 Modified Massey-Ferguson farm tractor with Kcpo ditcher.

Figure 4-3. Kopo ditcher in the treed area of the demonstration bog.

Figure 4-4. Field ditch immediately after being cut.

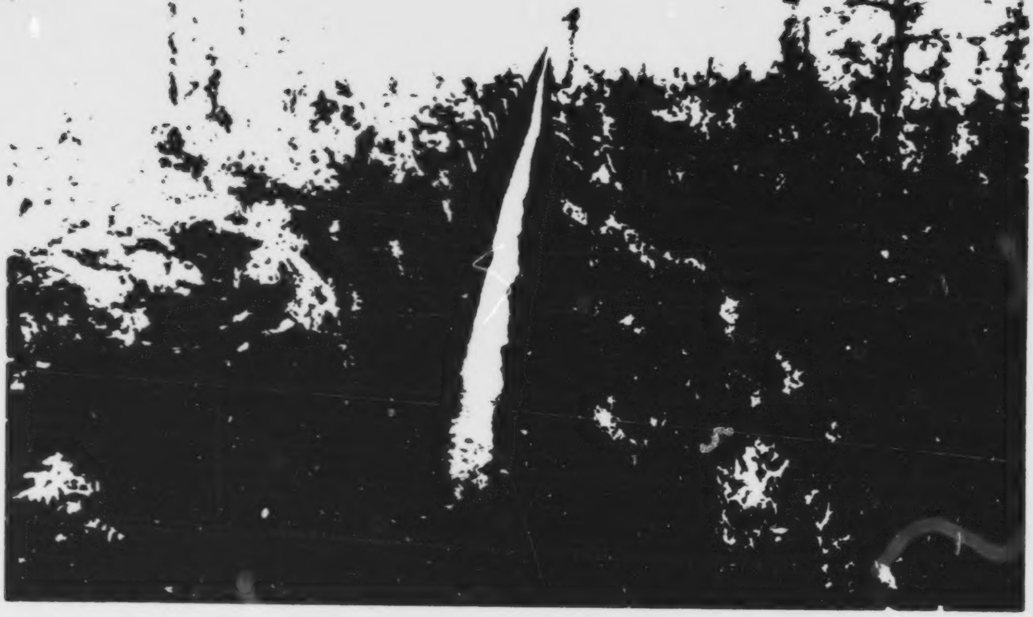


Figure 4-5. Field ditch shortly after being cut.

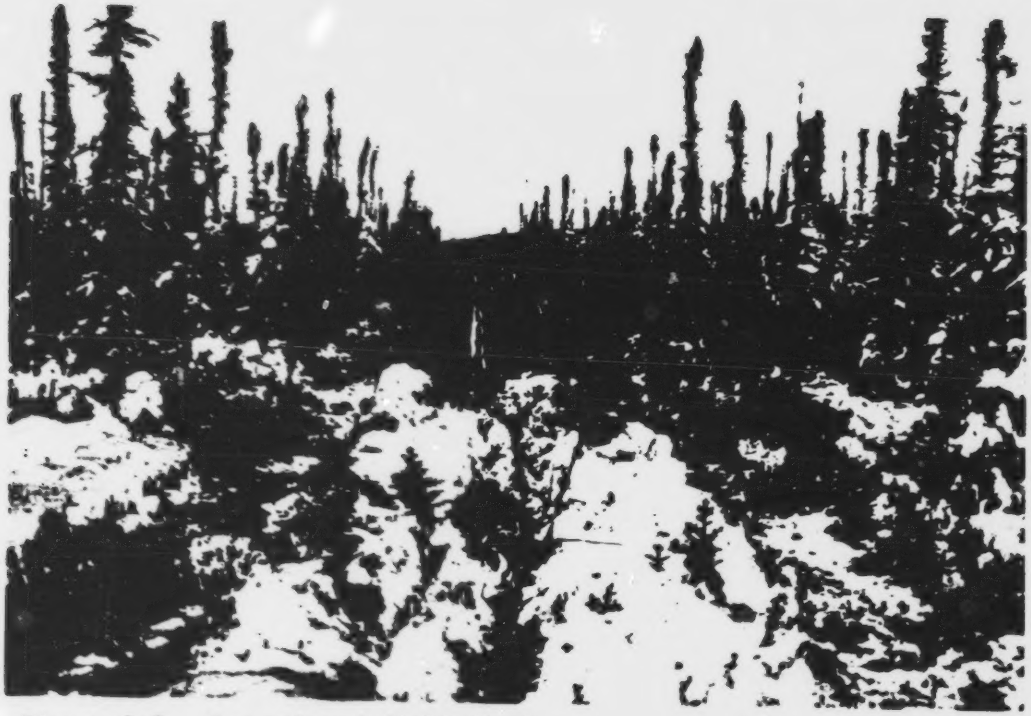


Figure 4-6. A completed field ditch.

Figure 4-7. Aerial view of the field ditches.

Figure 4-8. Excavating the perimeter ditch with a JSW excavator.

Figure 4-9. Partially ice-filled ditch after the first winter.

Figure 4-10. Partially blocked field ditch after the first winter.

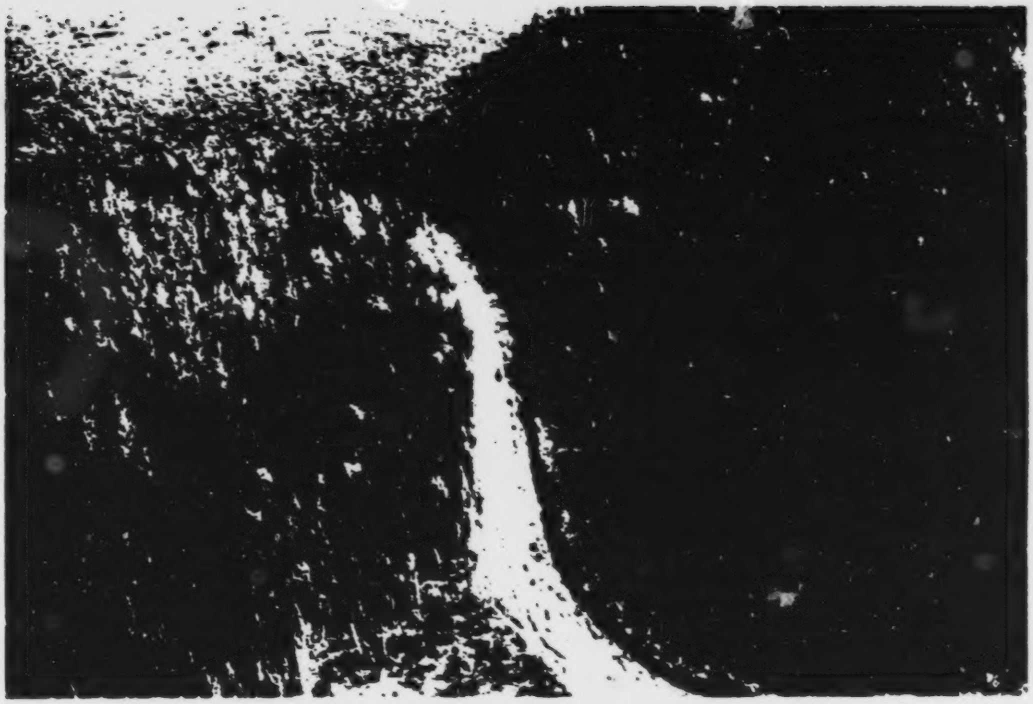


Figure 4-11. Eastern perimeter ditch from the air.

Figure 4-12. Western perimeter ditch from the air.

Figure 4-13. Western perimeter ditch after the first winter.

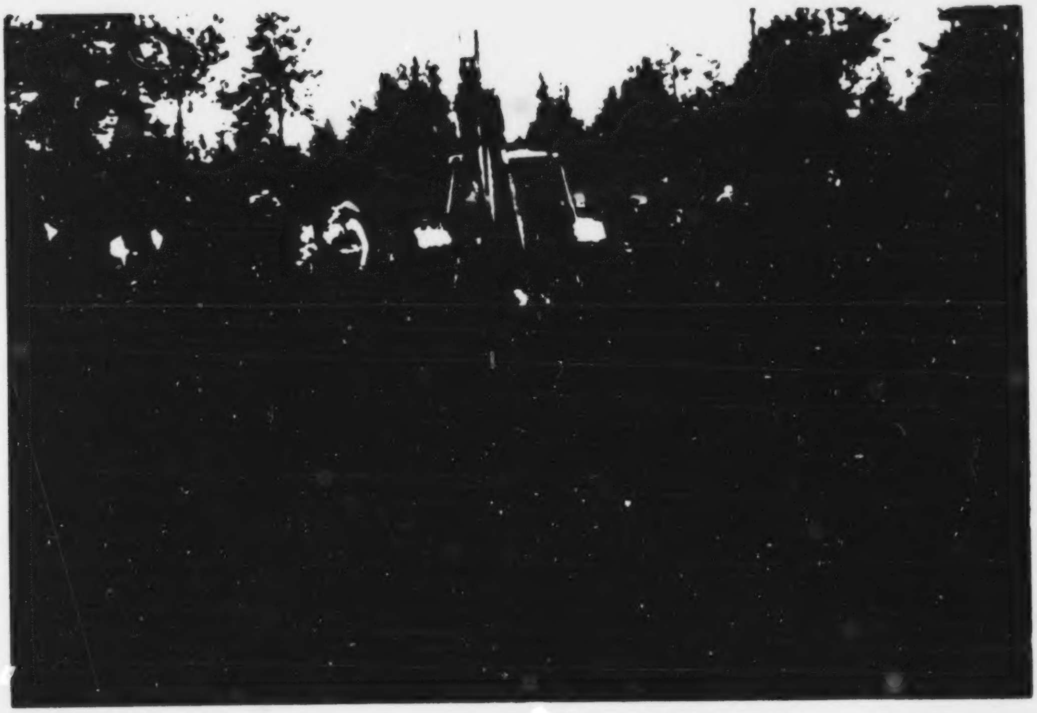
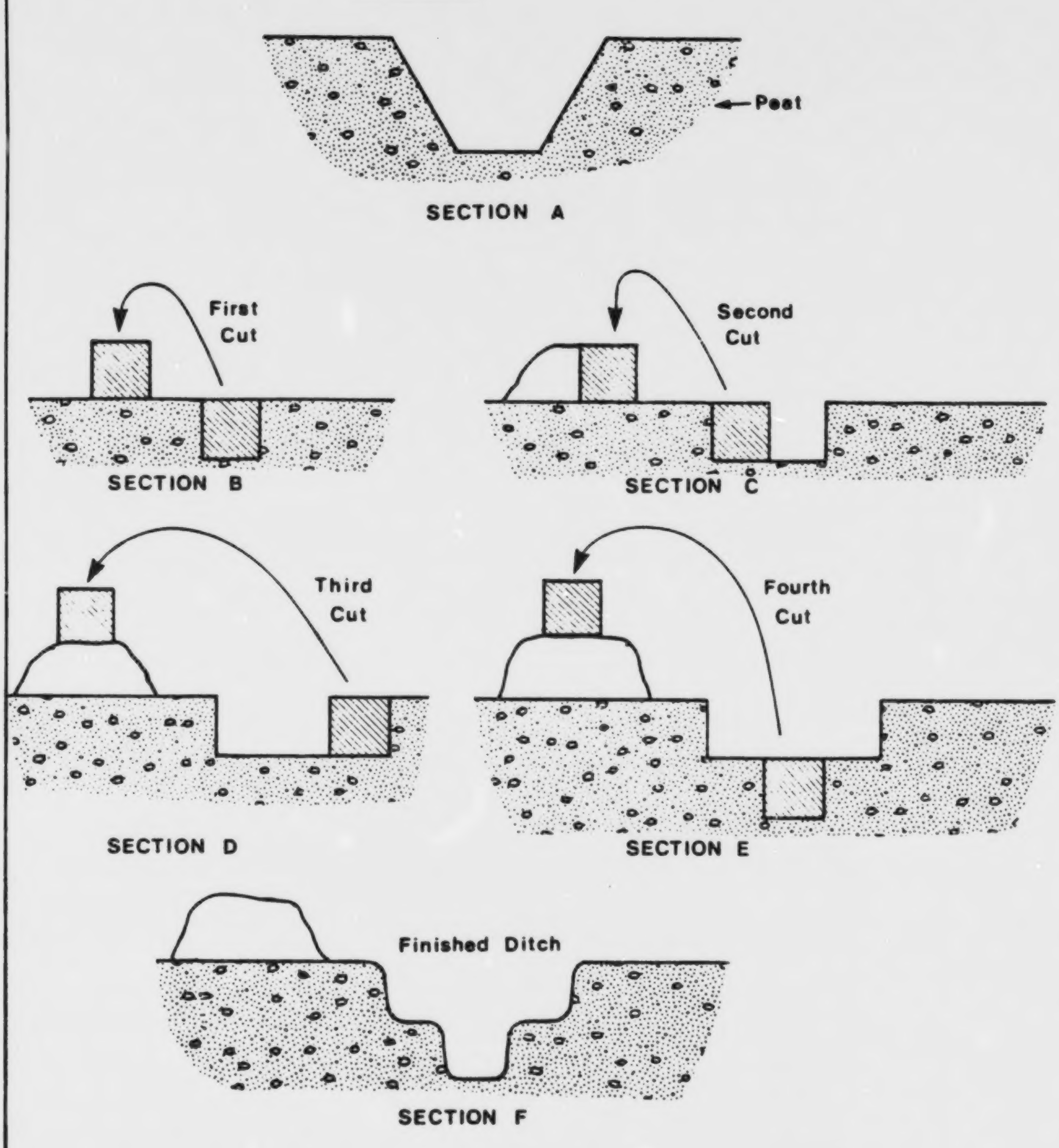


Figure 4-14. Specially formed peatland ditching bucket.


Peat
SECTION A
First
Cut
SECTION B
Second
Cut
SECTION C
Third
Cut
SECTION D
Fourth
Cut
SECTION E
Finished Ditch
SECTION F

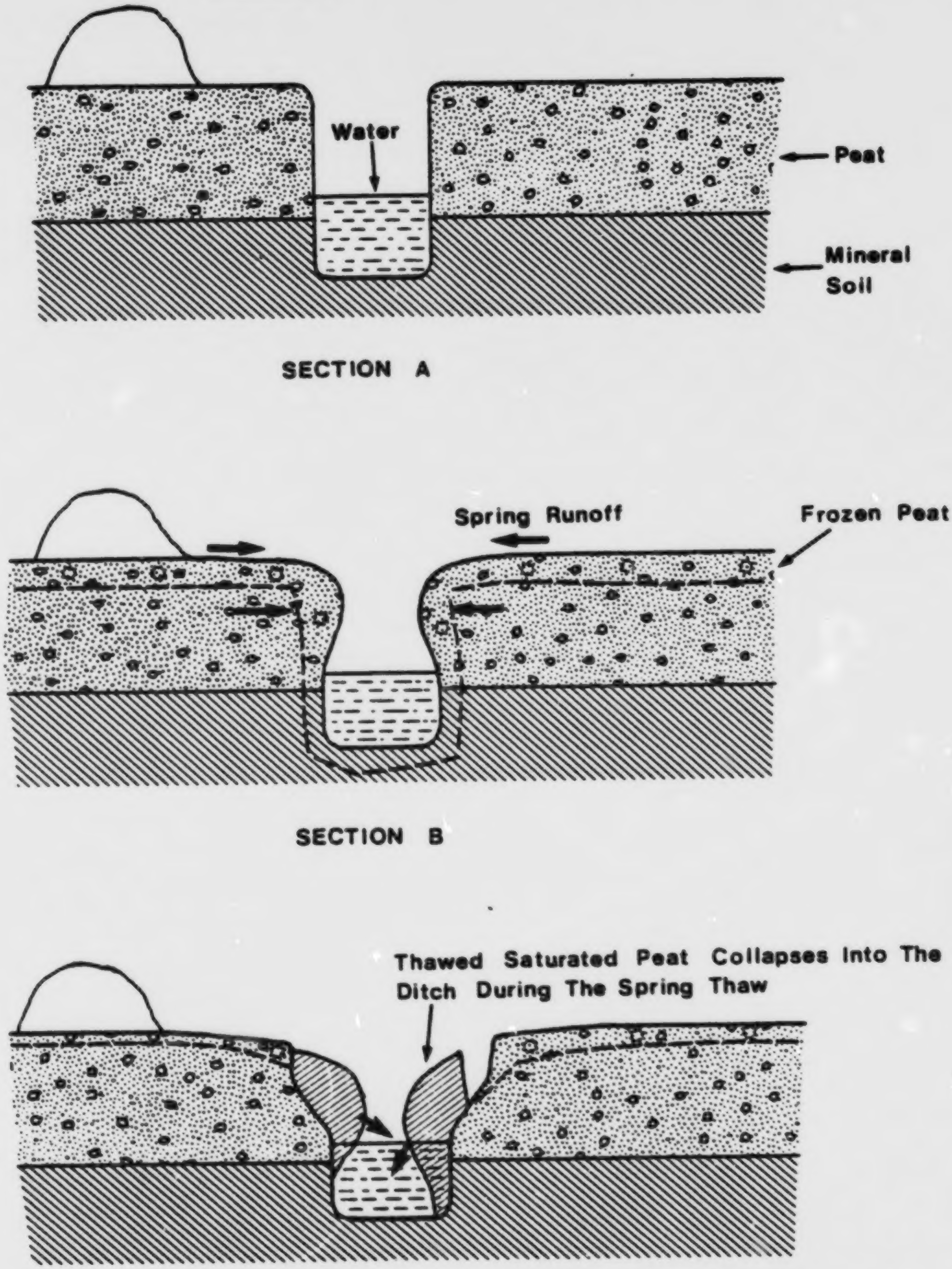
SECTIONS B TO F SHOW THE PROPER SEQUENCE FOR CUTTING A DITCH IN PEAT

SECTION A SHOWS THE IDEAL CUT MADE WITH A FORMED BUCKET

FIGURE 4-15

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

SCHEMATIC DIAGRAMS OF THE BOG DITCHING PROCEDURES


Water
Peat
Mineral Soil
SECTION A
Spring Runoff
Frozen Peat
SECTION B
Thawed Saturated Peat Collapses Into The Ditch During The Spring Thaw
SECTION C

SCHEMATIC DIAGRAMS SHOWING WHAT HAPPENS IN A DITCH CUT VERTICALLY INTO PEAT

FIGURE 4-16

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

SCHEMATIC DIAGRAMS OF VERTICALLY CUT DITCH

Figure 4-17. Backhoe clearing the western perimeter ditch.

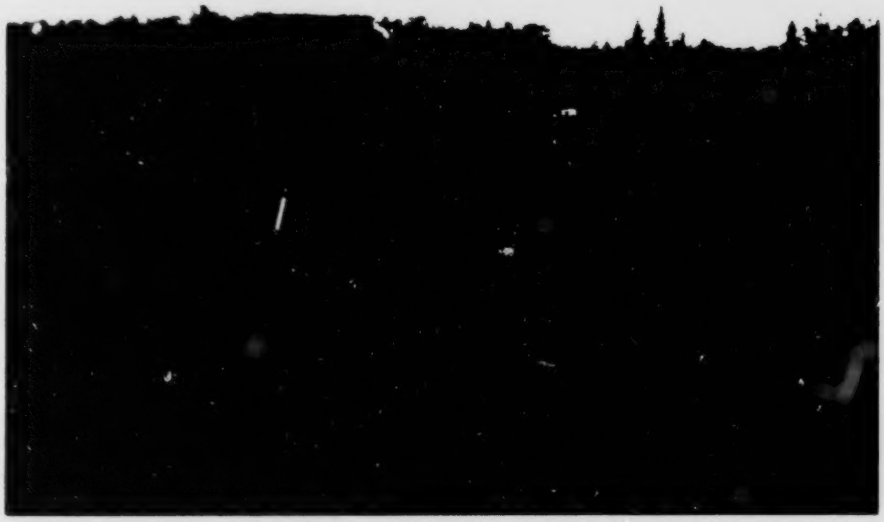


Figure 4-18. Dondi ditcher clearing a field ditch.

Figure 4-19. Access construction.

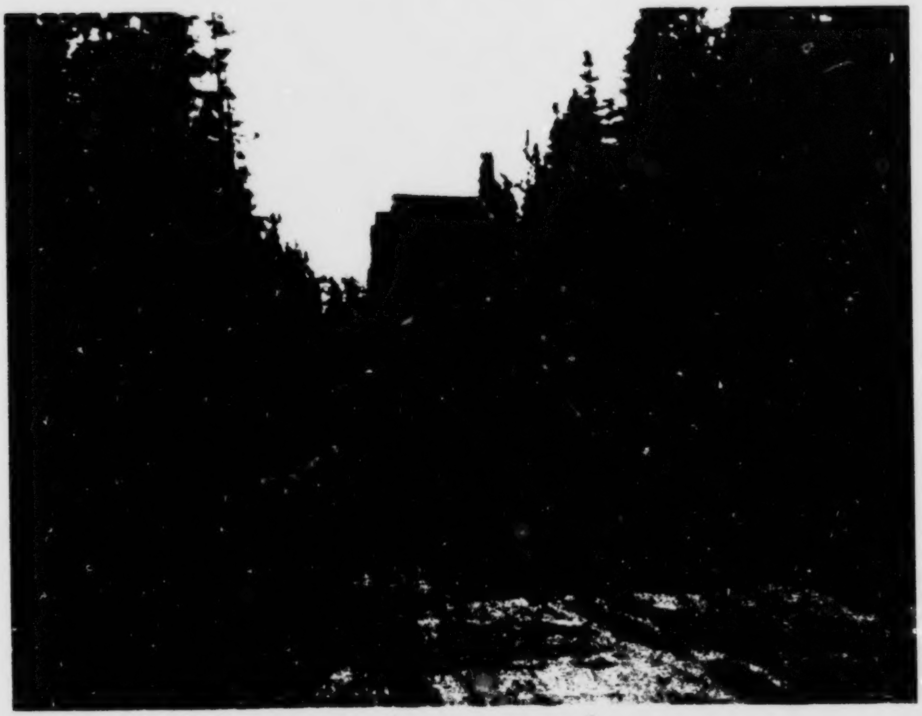


Figure 4-20. Gravelling the access road.

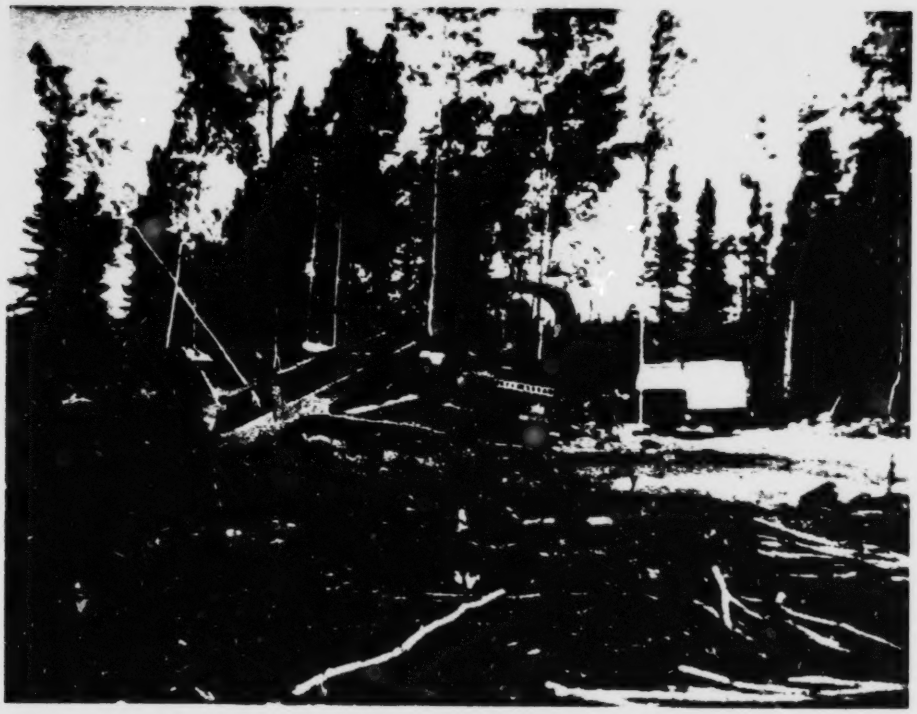


Figure 4-21. Clearing the storage area.

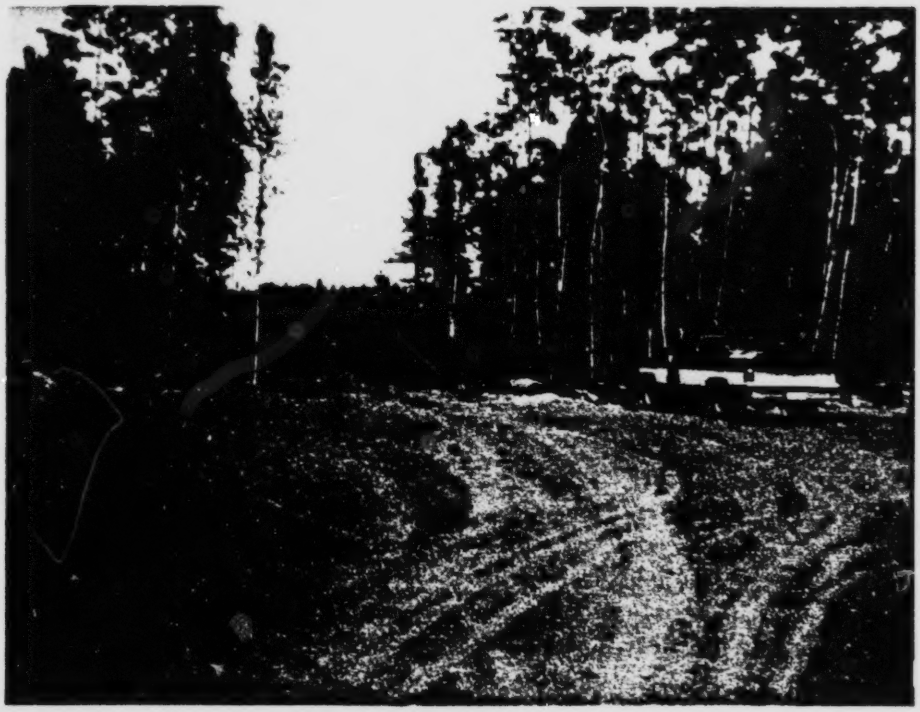


Figure 4-22. Finished storage area.

Figure 4-23. Perimeter ditch bridge.

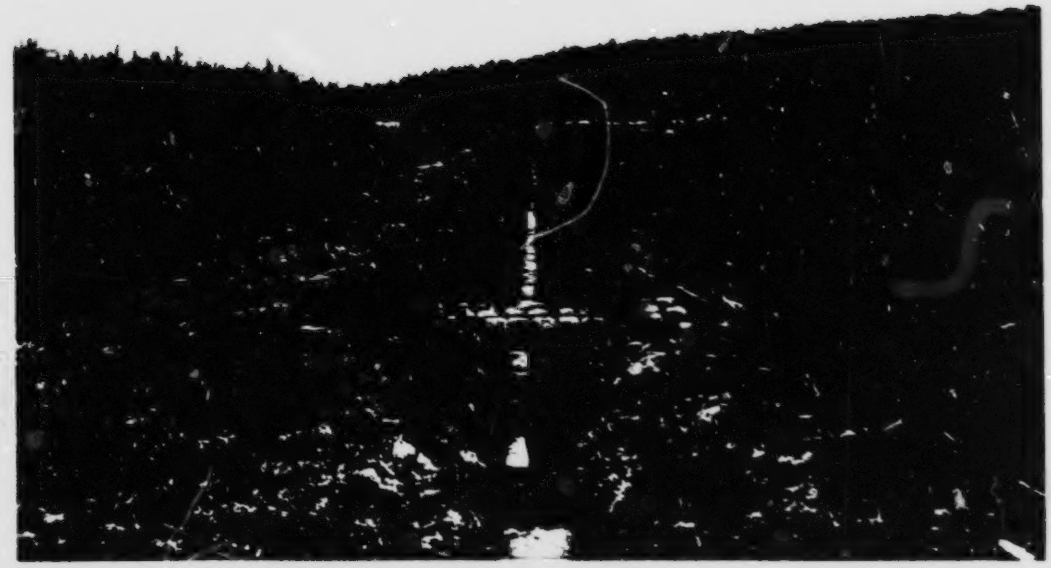


Figure 4-24. Field bridge.

Figure 4-25. Sedge - covered area of the demonstration bog in the background.

Figure 4-26. BEI cover; black spruce and shrubby vegetation originally present on the production fields.

Figure 4-27. Tree-pulling.

Figure 4-28. Tree-pulling.

Figure 4-29. Bog wagon hauling trees.

Figure 4-30. Cutting brush with a rotary mower.

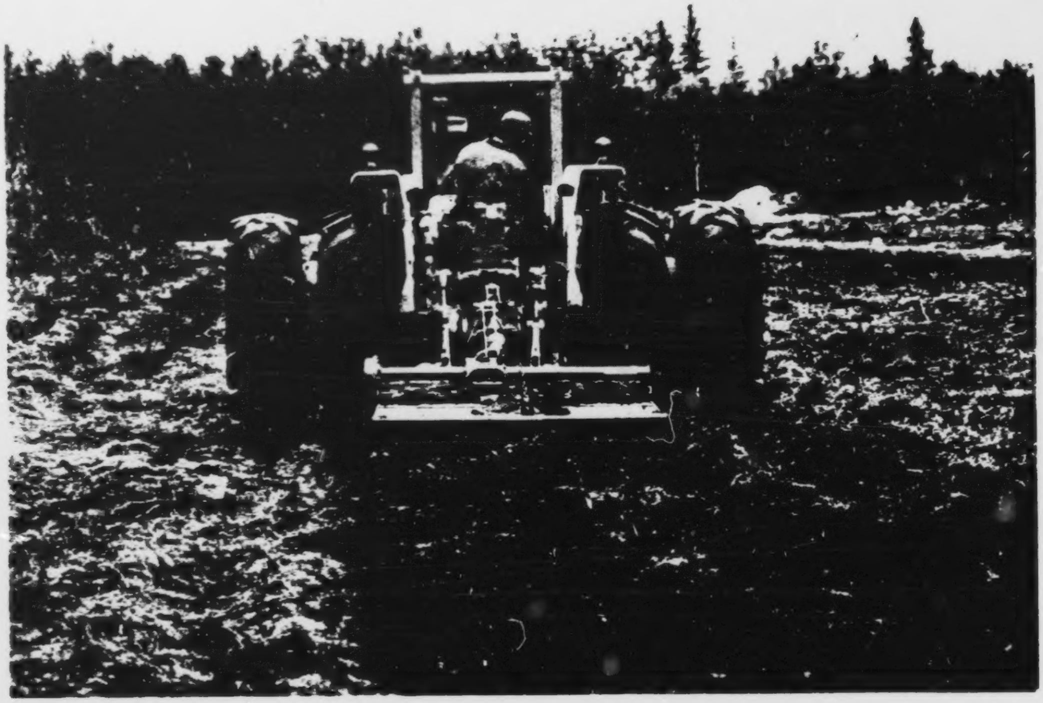


Figure 4-31. Rotovating the surface peat.

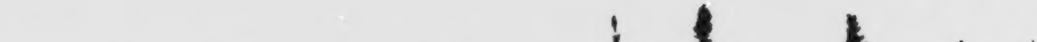


Figure 4-32. Screw-profiling the production fields.

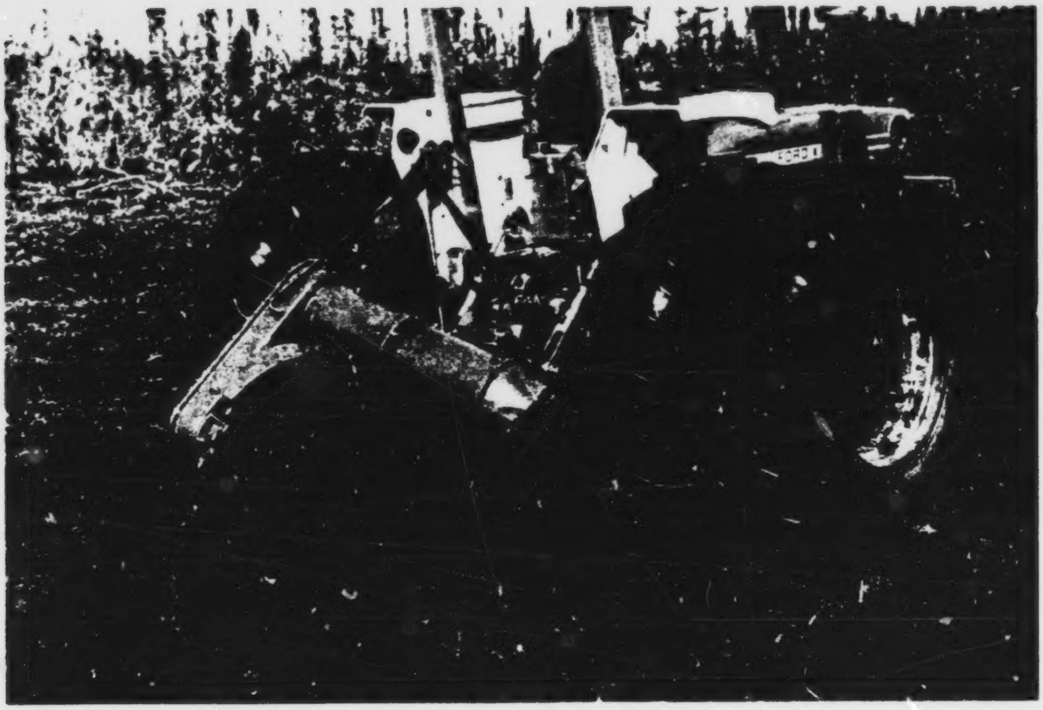


Figure 4-33. A Suokone Meri PK - 1A sod cutter.

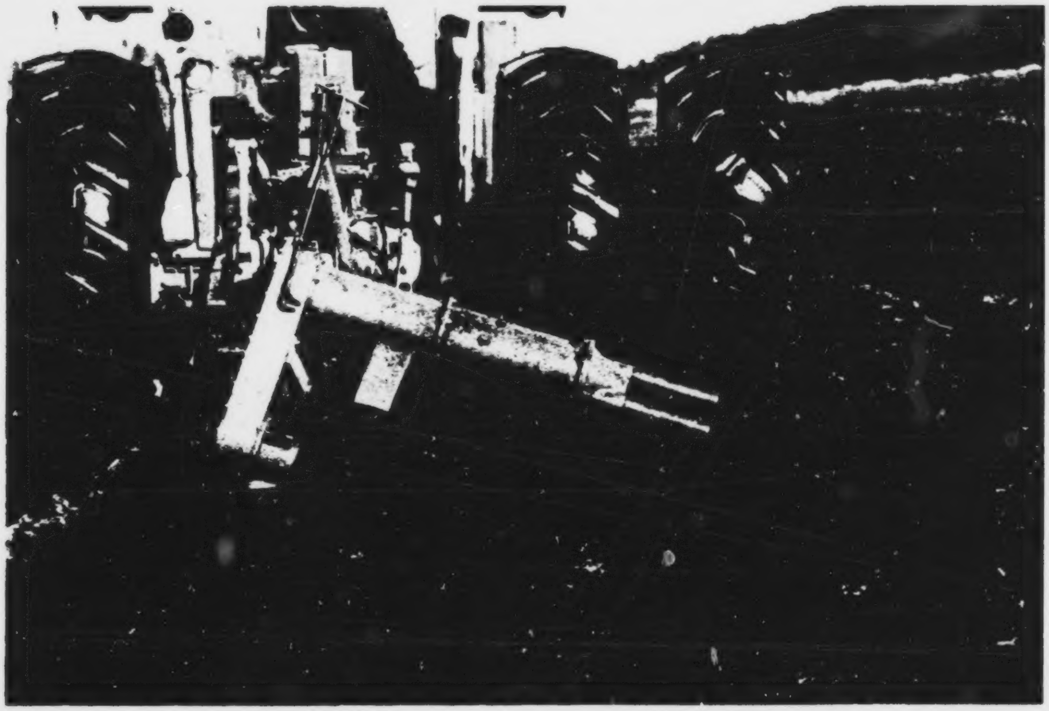


Figure 4-34. Sods produced at the Buffalo Narrows Demonstration Site.

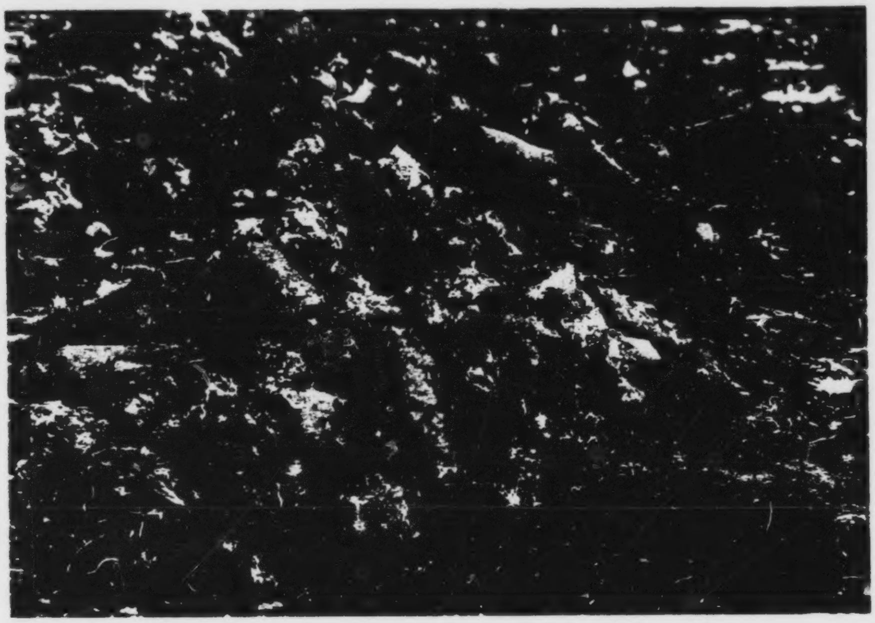


Figure 4-35. A close-up of some produced sods.

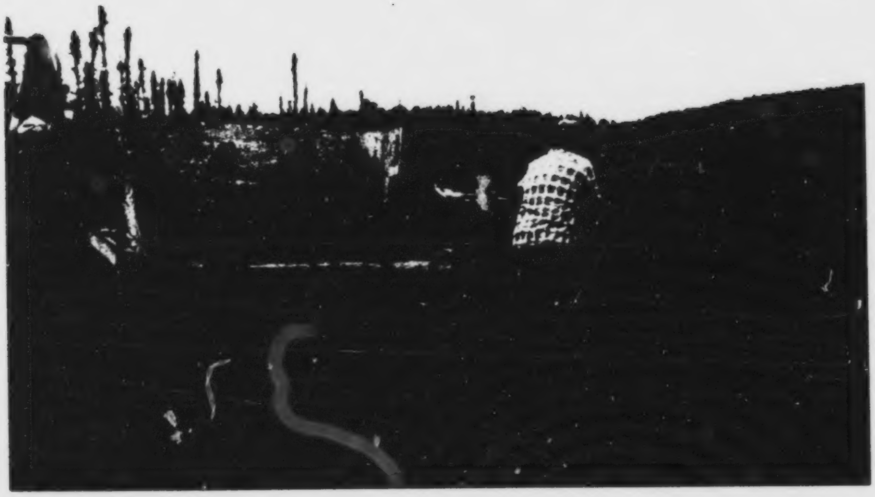


Figure 4-36. Sod collection.

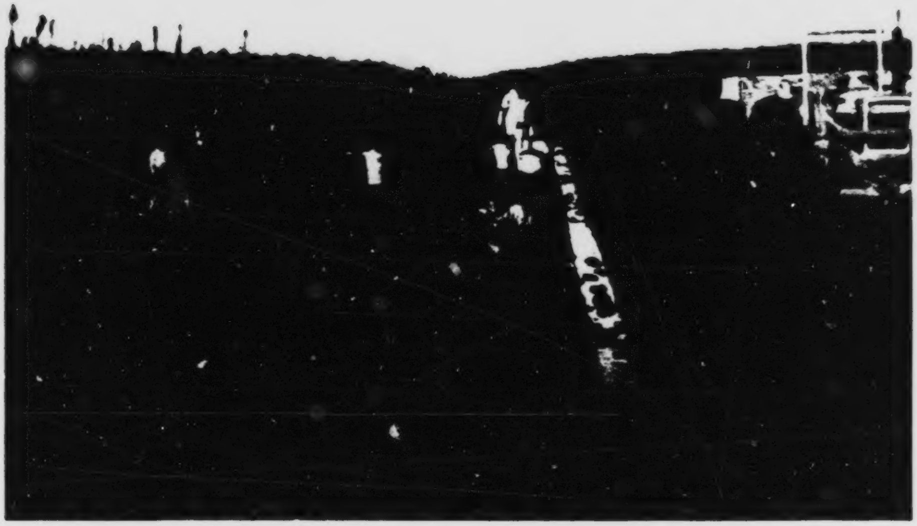


Figure 4-37. Sod collection.

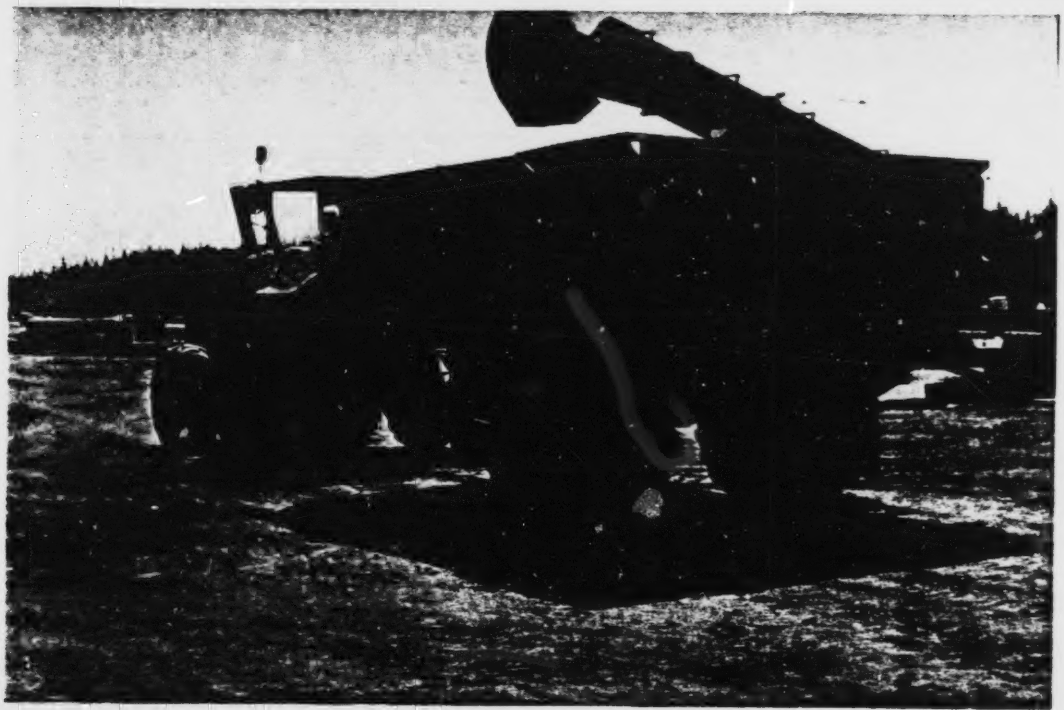


Figure 4-38. Nelos-Metalli bog wagon.

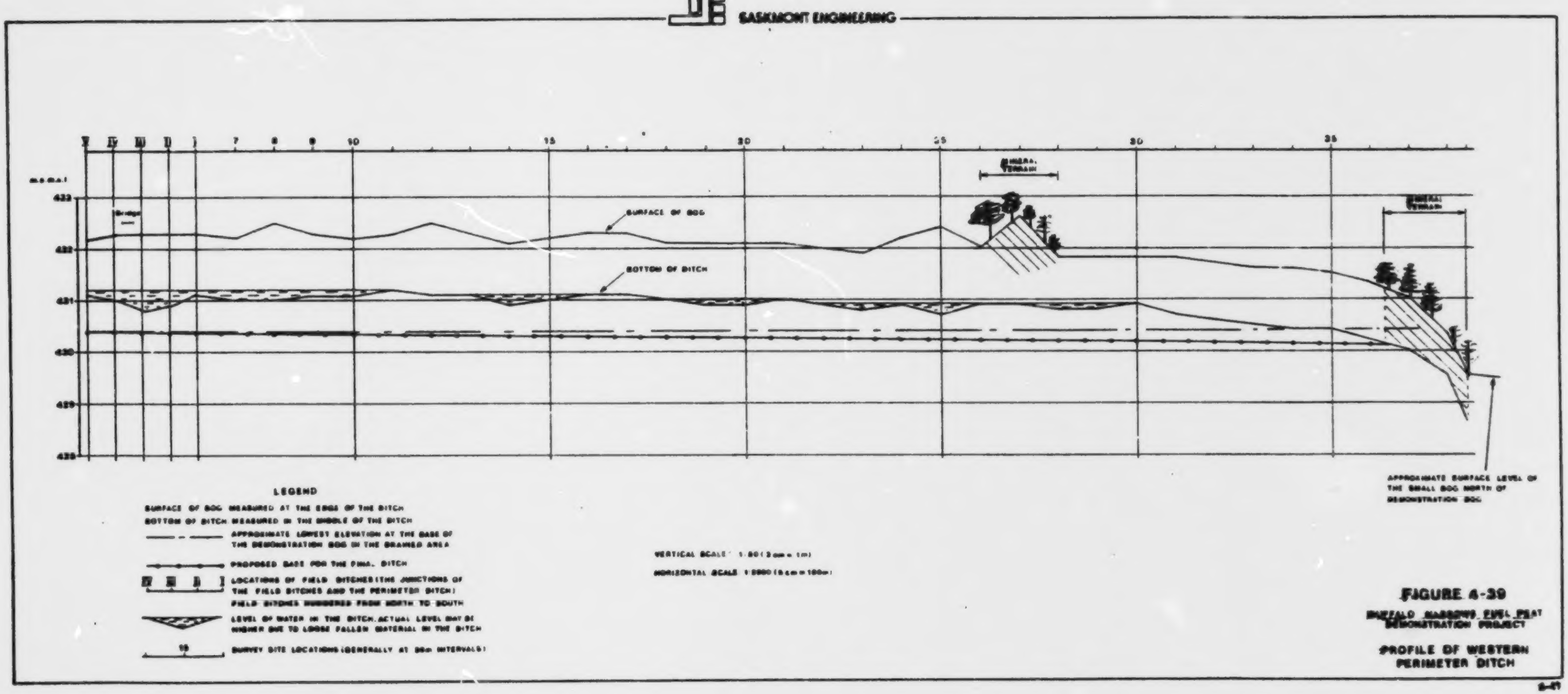
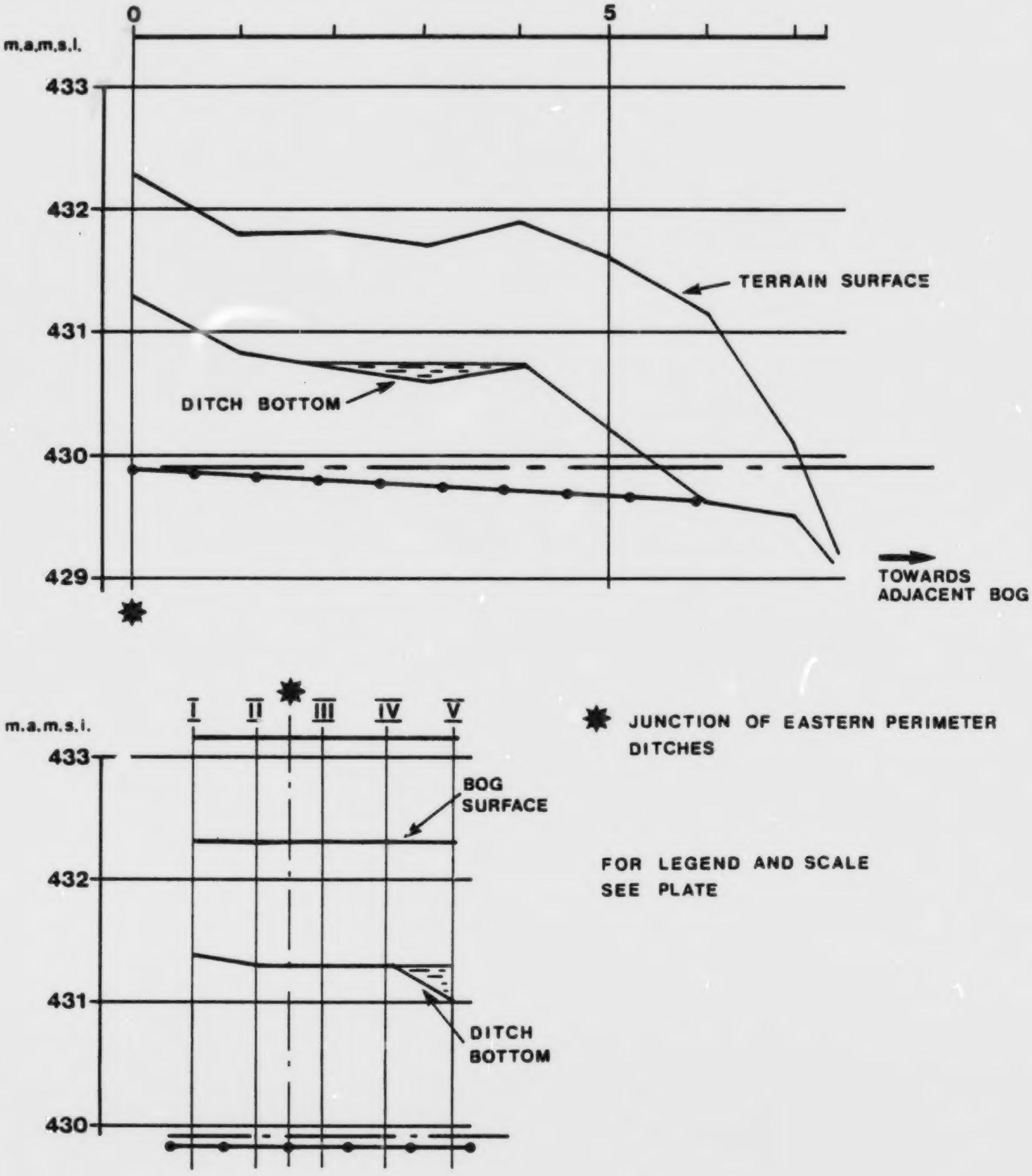

SASKMONT ENGINEERING
m.a.s.l.
432
431
430
429
428
V
IV
III
II
I
7
8
9
10
15
20
25
30
35
Bridge
SURFACE OF BOG
BOTTOM OF DITCH
MINERAL TERRAIN
MINERAL TERRAIN
APPROXIMATE SURFACE LEVEL OF THE SMALL BOG NORTH OF DEMONSTRATION BOG
LEGEND
SURFACE OF BOG MEASURED AT THE EDGE OF THE DITCH
BOTTOM OF DITCH MEASURED IN THE MIDDLE OF THE DITCH
APPROXIMATE LOWEST ELEVATION AT THE BASE OF THE DEMONSTRATION BOG IN THE DRAINED AREA
PROPOSED BASE FOR THE FINAL DITCH
LOCATIONS OF FIELD DITCHES (THE JUNCTIONS OF THE FIELD DITCHES AND THE PERIMETER DITCH)
FIELD DITCHES NUMBERED FROM NORTH TO SOUTH
LEVEL OF WATER IN THE DITCH. ACTUAL LEVEL MAY BE HIGHER DUE TO LOOSE FALLEN MATERIAL IN THE DITCH
10
SURVEY SITE LOCATIONS (GENERALLY AT 50m INTERVALS)
VERTICAL SCALE 1:50 (2 cm = 1m)
HORIZONTAL SCALE 1:2000 (5 cm = 100m)

FIGURE 4-39

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

PROFILE OF WESTERN PERIMETER DITCH



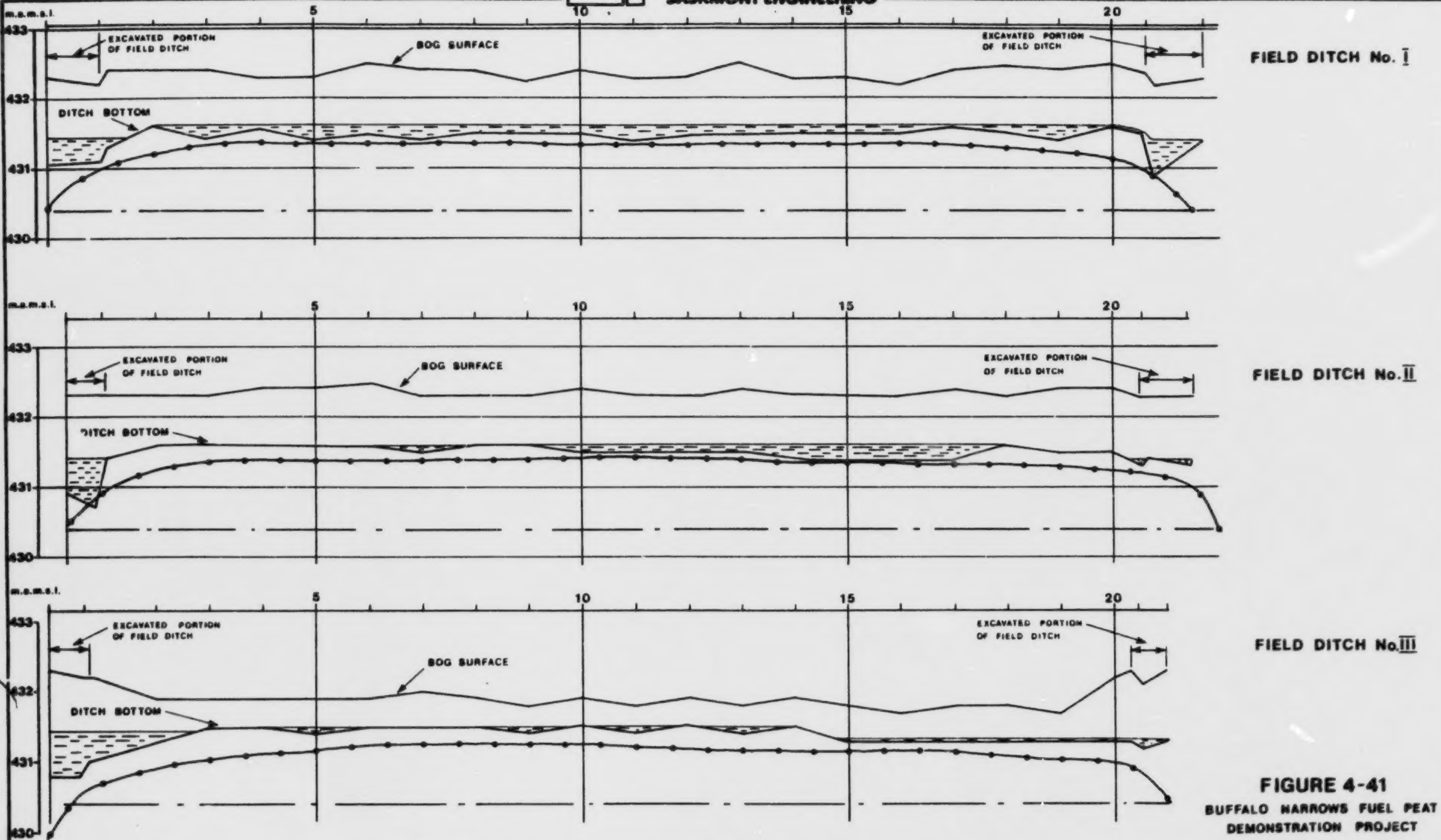
✱ JUNCTION OF EASTERN PERIMETER DITCHES

FOR LEGEND AND SCALE SEE PLATE

FIGURE 4-40

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

PROFILES OF EASTERN PERIMETER DITCHES


m.a.m.s.l.
433
432
431
430
5
10
15
20
EXCAVATED PORTION OF FIELD DITCH
BOG SURFACE
DITCH BOTTOM
FIELD DITCH No. I
FIELD DITCH No. II
FIELD DITCH No. III

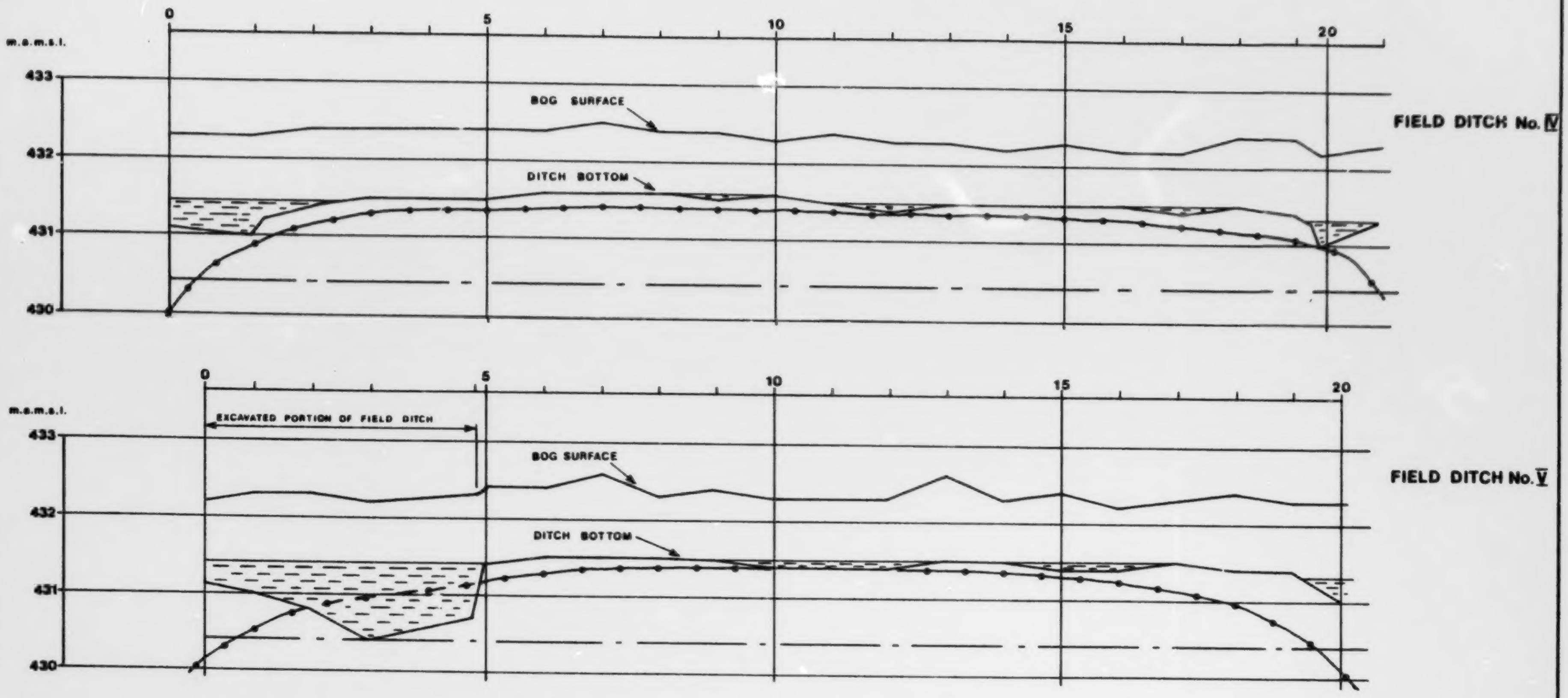
FOR LEGEND AND SCALE SEE PLATE 4-39

FIGURE 4-41

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

PROFILES OF FIELD DITCHES I, II, and III

SASKMONT ENGINEERING



FOR LEGEND AND SCALE SEE PLATE

FIGURE 4-42

BUFFALO NARROWS FUEL PEAT
DEMONSTRATION PROJECT

PROFILES OF FIELD DITCHES
IV and V

SASKMONT ENGINEERING

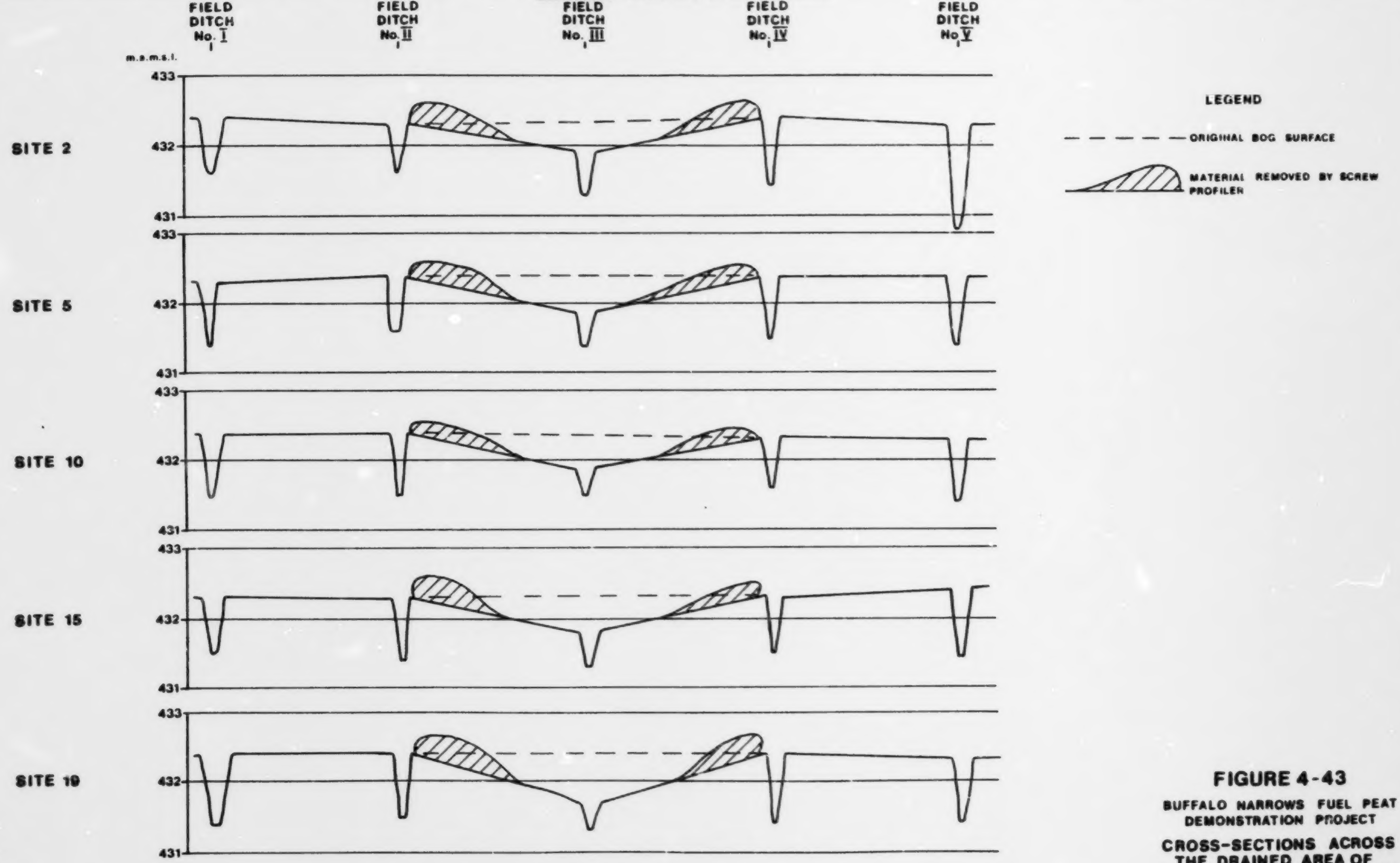


FIGURE 4-43

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

CROSS-SECTIONS ACROSS THE DRAINED AREA OF THE DEMONSTRATION BOG

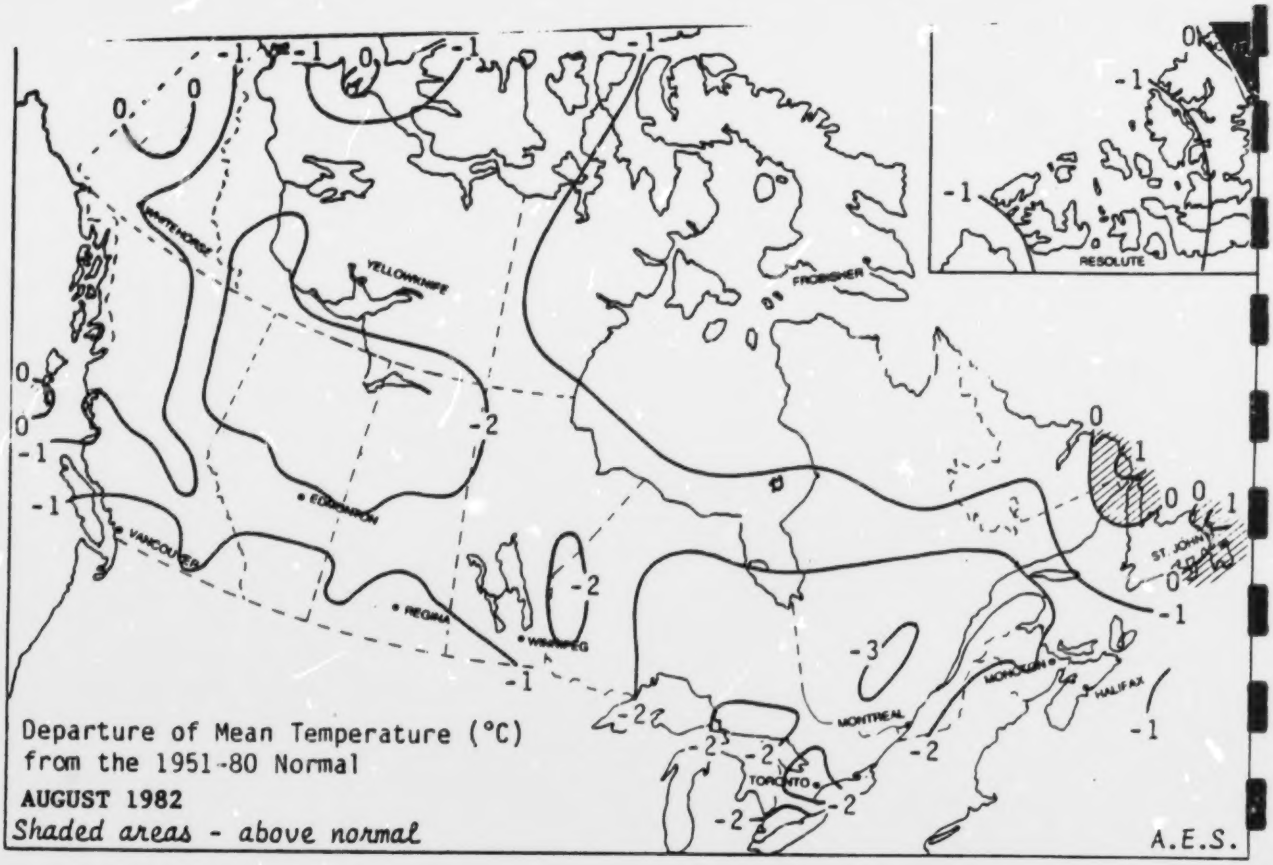

Departure of Mean Temperature (°C)
from the 1951-80 Normal
AUGUST 1982
Shaded areas - above normal
A.E.S.
WHITEHORSE
YELLOWKNIFE
FROBISHER
EDMONTON
VANCOUVER
REGINA
WINNIPEG
TORONTO
MONTREAL
MONCTON
HALIFAX
ST. JOHN'S
RESOLUTE
-3
-2
-1
0
1

Figure 4-44. Departure of Mean Temperature from the 1951-1980 Normal - August, 1982.

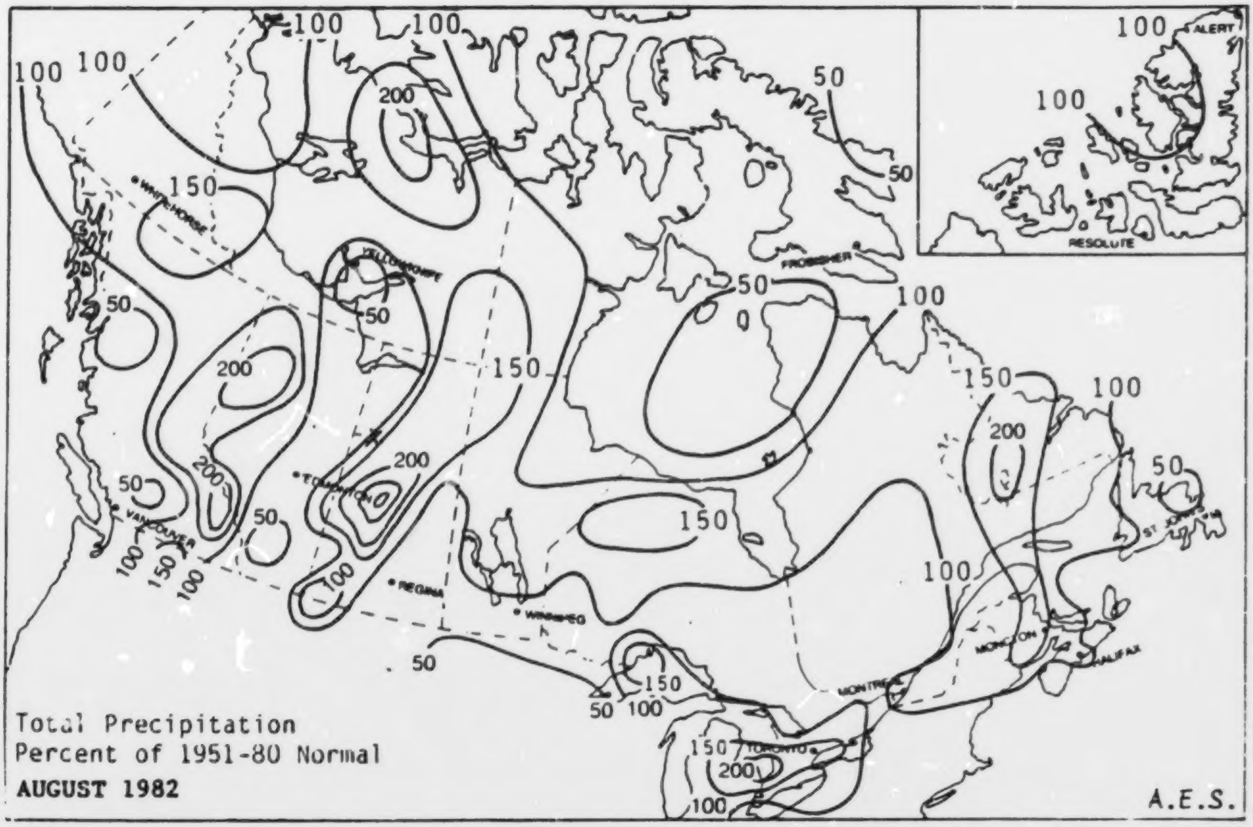

Total Precipitation
Percent of 1951-80 Normal
AUGUST 1982
A.E.S.
WHITEHORSE
YELLOWKNIFE
EDMONTON
VANCOUVER
REGINA
WINNIPEG
FROBISHER
ALERT
RESOLUTE
MONTREAL
TORONTO
MONCTON
HALIFAX
ST JOHN'S
100
150
200
50

Figure 4-45. Total Precipitation Percent of 1951-1980 Normal - August, 1982.

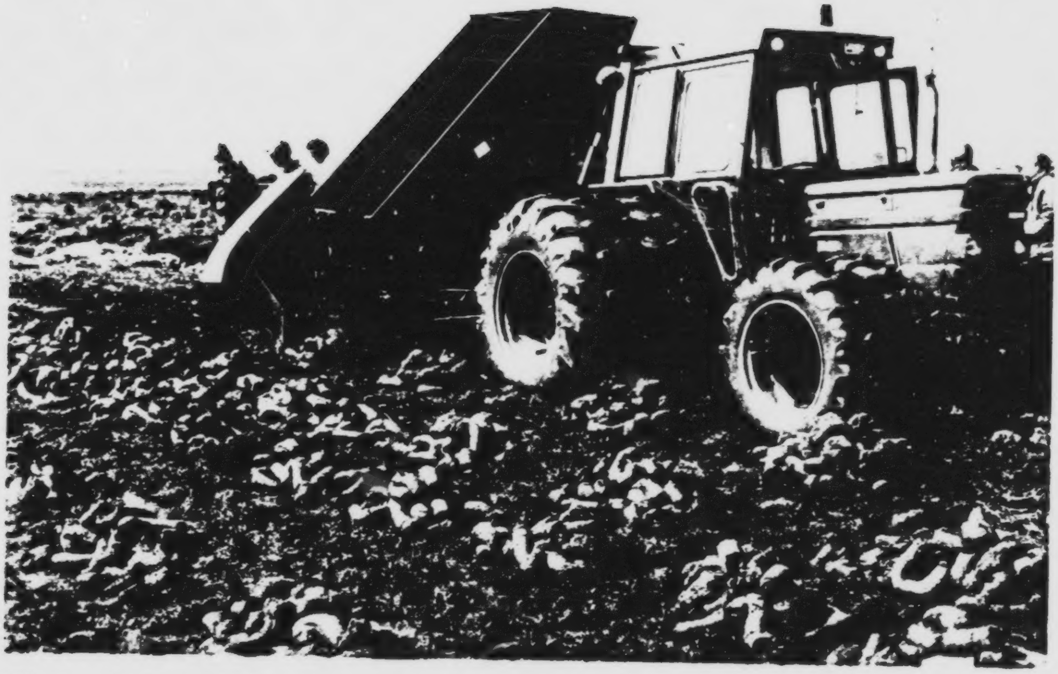


Figure 4-46. Sod peat collection machine.

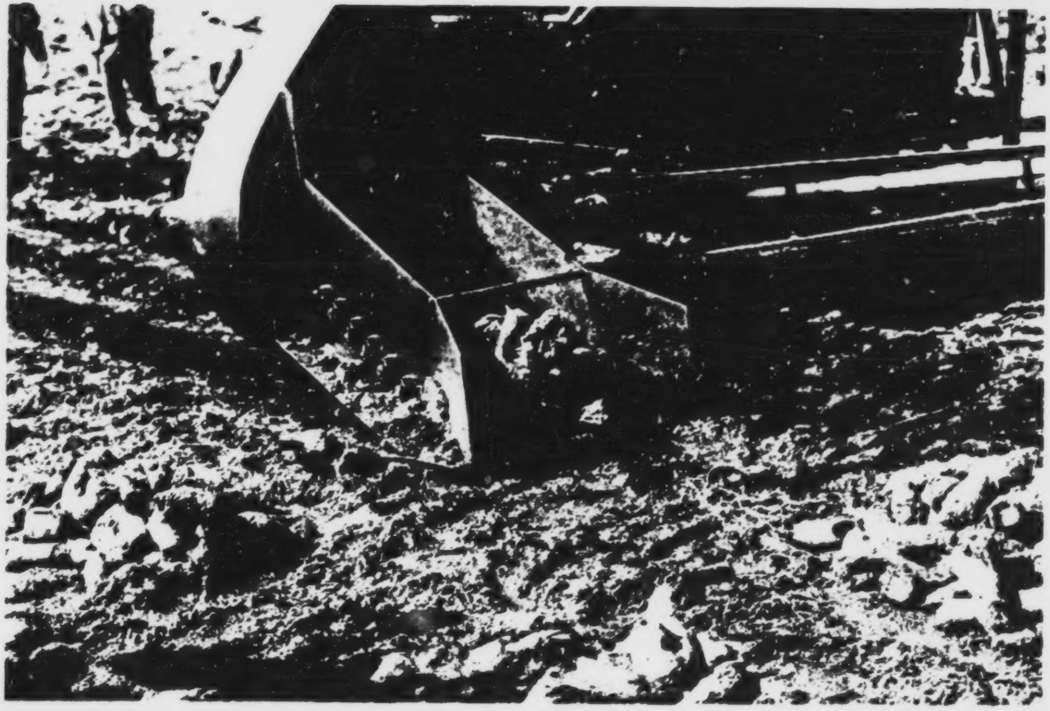


Figure 4-47. Sod peat collection machine.

PART 5

HOME HEATING TRIALS

PART 5 - HOME HEATING TRIALS

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5.0 HOME HEATING TRIALS

5.1 PREVIOUS STUDIES

In 1978/1979, Saskmont Engineering Company Limited compiled information detailing population distribution, type of housing, types of heating systems, types of fuels used, cost of fuel, and energy consumption pattern by type of fuel and end-use for Buffalo Narrows and the surrounding communities. Further updating of the information took place in 1980/1981 during a subsequent study which examined the utilization of peat in Buffalo Narrows and its environs (See Table 5-1).

The 1979 report, identified that oil and wood were largely being used for space heating with minor amounts of electricity and propane. In the study released in 1981, following a preliminary survey conducted to determine the number of multi-fuel heating furnaces installed in Department of Northern Saskatchewan (DNS)/Local Housing Group (LHG) recently constructed homes, it was reported that in Buffalo Narrows and the nearby area (Dillon and Michel Village) there were 115 wood-fired heating units and another 73 dwellings with multi-fuel furnaces. Thus, in this area alone it was found that there were 188 dwellings which could potentially utilize peat as a fuel for their space heating requirements (See Table 5-2).

Early in the study it became apparent that the potential for utilizing fuel peat for domestic use was largely dependent upon whether peat would burn in the existing multi-fuel furnaces, how efficiently it would burn and at what rate as well as the cost of converting the furnaces to burn peat, if required as well as on the consumer acceptance. The two manufacturers providing domestic multi-fuel furnaces to DNS and the LHG agreed to conduct burn tests of peat in their laboratories. For the purposes of the tests, 400 kg of

TABLE 5-1

Estimate of Current Distribution of Home Heating Fuels by Type

Community	Total Units (1978/79)	Population Increase (Annual %)	Total Units (1980/81)	Electricity		Oil		Gas		Wood	
				Units	%	Units	%	Units	%	Units	%
Beauval	145	nil	145	-	-	110	76	-	-	35	24
Buffalo Narrows	299	9	355	6	1	298	85	6	1	45	13
Nearby Area	120	5	132	-	-	62	47	-	-	70	53
Ile a la Crosse	215	8	251	-	-	201	80	-	-	50	20
La Loche	330	6	371	-	-	225	61	6	1	140	38
La Ronge*	1,045	8	1,219	-	-	1,019	84	-	-	200	16

Assumptions:

(1) The total number of units has increased in proportion to population.

(2) The number of wood heated units has remained constant.

(3) The number of electric and gas heated units has increased as population increases.

(4) The number of oil units represent the balance of the increase and includes homes heated with multi-fuel units.

* Included for information purposes.

TABLE 5-2

Distribution of Domestic Furnaces in DNS Housing Units
(Buffalo Narrows Area)

Community		1977		1978		1979		1980		Totals
		DNS Public	LHG(1)	DNS Public	LHG	DNS Public	LHG	DNS Public	LHG	
Beauval	T (2)	7	0	6	5	7	7	6	10	48
	MF(3)	0	0	6	5	7	7	6	10	35
Buffalo Narrows	T	8	0	10	10	12	12	0	20	72
	MF	0	0	10	6	12	6-7	0	19	53-54
Ile a la Crosse	T	10	10	6	10	8	16	0	20	80
	MF	10	0	6	6	5	10	0	20	57
La Loche	T	19	0	–	–	10	12	10	6	57
	MF	0	0	–	–	10	9	10	6	35
St. Georges Hill	T	2	0	3	–	0	3	0	3	11
	MF	0	0	3	–	0	3	0	3	9
Michel Village	T	2	0	4	–	0	3	3	0	12
	MF	0	0	4	–	0	3	3	0	10
	Total (Multi-fuel)									280 (200)

Notes: All DNS public homes have mutli-fuel furnaces since 1978.
(1) Local Housing Group
(2) T = Total
(3) MF = Multi-fuel furnaces
Source: Communications with Department of Northern Saskatchewan.

sod peat and 300 kg of peat briquets were imported from Finland.

In all, 3 multi-fuel furnaces were tested namely: Newmac wood/oil furnace models CL 86 C (no grates) and CL 86 G (with grates) and an Inter-City furnace model MFA 112. Prior to the testing, the grate on the Inter-City furnace was slightly modified at a cost of $40 each in addition to changing the ignition point.

The test results were encouraging regarding the use of sod peat in the existing Canadian-built multi-fuel furnaces which had been mainly designed for wood to be used as the alternative solid fuel. Although the testing was of a preliminary nature and left many questions unresolved, nevertheless, it revealed that peat burned well in the existing multi-fuel furnaces. The testing confirmed that both briquets and sods ignited and burned comfortably in the furnaces. It was noted that sods burned similarly to low grade wood and had a similar heat distribution within the Inter-City unit. In the Newmac furnaces it was found that the sods burned more efficiently and with greater heat output in the G model while in the C model the fire was easier to control. In all three furnaces no noticeable accumulation of creosote residue was detected within the combustion area or on any heat transfer surfaces. During the testing, distinct odors were noted. The odors emanating from the Newmac furnaces were described as being potentially displeasing to the homeowner. No such comment was made regarding the Inter-City furnace although some odors were detected originating from the flue. Besides odor, a smoke problem was also noted during the Newmac furnace testing. Apparently, during one of the loading periods, smoke escaped from the firedoor. This was considered avoidable by proper start-up procedures.

No absolute determinations of combustion efficiency were carried out; only indications of possible consumption and burn rates were ascertained. For the most part, the furnace testing was conducted under runaway conditions whereby rated capacities of the furnaces could be determined. In spite of this, Newmac and Inter-City reported that a full load of sods would burn for 4 and 5 hours in the respective units under normal conditions. In addition, they reported that a consumption rate of 4.5 to 5.9 kg/hr (35% moisture sod peat) could be expected under normal heating conditions.

The previous discussion centered on the combustion of sod peat. Briquets were burned in the Inter-City unit and generally exhibited superior combustion qualities than did the sods. However, due to sod peat production being envisaged for Buffalo Narrows, testing of sod peat combustion was more heavily emphasized.

Although some sod peat consumption rate figures were roughly determined only an actual field trial, where sod peat would be burned in properly monitored homes in the Buffalo Narrows area, could provide realistic annual peat consumption figures.

5.2 BUFFALO NARROWS HOME HEATING TRIALS

521 Introduction

To complement the sod peat production demonstration at Buffalo Narrows, a separate demonstration project was set-up in which the performance of several multi-fuel furnaces presently in use in Buffalo Narrows homes and three other imported furnaces designed specifically for peat firing were to be evaluated under actual typical home heating conditions over the course of two winters. During this testing, sod peat procured from Finland and eventually sod peat produced at the demonstration bog were to be used to fire the furnaces. Besides providing a basis on which to evaluate the performance of the furnaces for residential space heating, it was also intended that the testing would afford more reliable peat consumption figures in order to arrive at a more accurate annual peat demand.

522 FURNACE PERFORMANCE TESTING IN PRINCE ALBERT

.1 Introduction

In the fall of 1981, 2 peat-burning furnaces of Finnish design were purchased in order to evaluate their suitability for home heating in Buffalo Narrows. A multi-fuel furnace of German design which was donated to the project by the manufacturer, was also incorporated into the testing program. For the purposes of the furnace evaluations, and since it was anticipated that very little or no sod peat would possibly be produced at the demonstration bog in the first year, 20 tonnes of Finnish sod peat were purchased.

The Saskatchewan Research Council (SRC) was retained to carry out the performance testing and to monitor the furnaces during the home heating demonstration tests. In addition to this, SRC assisted DNS with the selection of the test-homes in Buffalo Narrows. The following information on the results of the furnace testing program is taken in large part from the two SRC reports on the results of the work.

Early on, partly due to delays in equipment deliveries as well as foreseeable operational and de-bugging problems associated with the furnace testing, the actual installation of the heating units into the Buffalo Narrows homes was deferred until the summer of 1982. Also, it was felt that it might be wiser to conduct an initial test-firing of the furnaces in an industrial building (DNS) in Prince Albert, where it would be easier, safer and more economical to mitigate any problems associated with the equipment. As it turned out, some of the units were partly assembled when received while others required modification to various components such as control systems which were in some cases incomptabile with Canadian electrical standards. By being in Prince Albert as opposed to Buffalo Narrows, these problems were more easily rectified.

.2 Furnaces

The three multi-solid-fuel type furnaces test-fired in Prince Albert for the demonstration project were the Arimax 25, the Hakas TP22 and the Viessmann Mono F. In addition to the Hakas furnace, a Hakas 1000 L water tank and fuel hopper supplied with an automatic feeding mechanism were also purchased. The Arimax and Hakas equipment were designed and built in Finland while the Viessmann was designed in West Germany but assembled in Waterloo, Ontario.

The Arimax 25 unit is a multi-solid-fuel furnace with a base burner steel boiler. Its approximate dimensions are 1.0 m high by 0.5 m wide by 0.9 m deep. The feeding door and access to the interior for cleaning are at the top of the unit. The primary air entrance is at the front, with an automatic damper. The secondary air entrances are at the sides. These are available with automatic controls, however, they were not supplied.

The Hakas TP-22 unit is a multi-solid-fuel furnace supplied with a base burner steel boiler. Its approximate dimensions are 1.5 m high by 1.0 m wide by 1.0 m deep. The primary and secondary air intakes are at the front and each has a damper whose action is controlled through a coupling to a water jacket thermostat system. The secondary combustion chamber has a separate access door and viewing window.

The Viessman Mono F unit is also a multi-solid-fuel furnace with a base burner steel boiler. Its approximate dimensions are 1.2 m high by 0.6 m wide by 0.6 m deep. The unit has front cleaning and loading access, with cast iron doors and water cooled grates. The primary air damper is controlled through a coupling to a water jacket thermostat system. The secondary air damper is manually adjusted, and is of a rosette design.

.3 Furnace and Monitoring Equipment Instrumentation

In preparing for the performance testing in Prince Albert, an attempt was made, wherever possible, to try to duplicate the actual conditions that would be encountered if the furnaces were installed in a house rather than in the DNS structure where the performance test took place. In this regard, the flue design was critical. Following some research, SRC personnel designed a flue made of 177 mm black stove pipe and class 'A' flue sections. The total vertical height of the flue was 4.57 m, of which 3.66 was above roof level. Shorter runs of connecting pipe were made between the test furnaces and the main flue at an angle of 45 degrees to horizontal. This brought the total vertical height of the flue system to 5.77 m, which was fairly representative of a typical house installation. With this design it was expected that there would be a draft of 2.28 mm of H_2O, assuming an ambient pressure of 1.0 atmosphere, an ambient temperature of 20°C, an estimated mean flue gas temperature of 200°C and a flue efficiency of 90%.

For test purposes, the furnaces were connected to a 1000 L uninsulated storage tank, using 2.54 mm standard pipe. For all tests, a Danfoss self-contained modulating control valve was in the water circuit to conform with the manufacturer's control requirements (see Fig. 5-1). The valve controlled the return water temperature in the mixing circuit that as shown. A Bell and Gosset circulation pump was used for the Arimax tests. This was found to be inadequate for the later tests on the other two furnaces, which had a recommended flow rate of 21 L per minute. A Grundfos pump was used for these two tests.

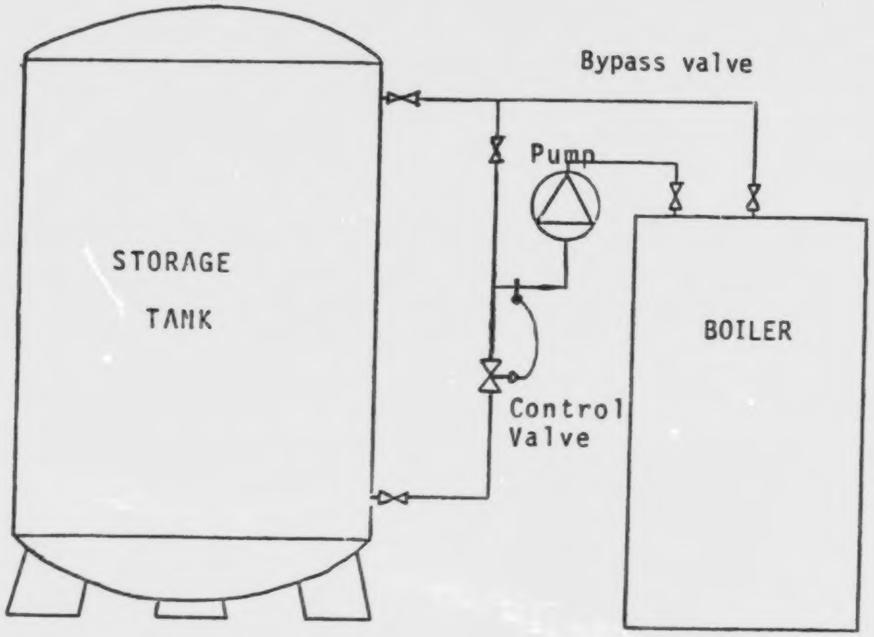
A residential heating load was simulated by circulating the heated water from the storage tank through a fan-coil space heating system. This circuit consisted of a Bell and Gosset pump and two alcohol thermometers mounted in 'wells' in the circuit, measuring the temperature drop across the fan-coil unit. The arrangement is shown in Figure 5-2.

Thermocouples were used to measure the flue gas temperature at the furnace exit, roof level and the chimney exit as well as the temperature of the return and supply water, the outside air and the air being fed to the furnace.

.4 Findings

SRC reported that the ignition procedures for the Arimax 25 and the Viessmann Mono F were quite simple resulting in the sod peat being ignited very easily using newspapers and kindling. Conversely, the ignition procedure for the Hakas TP 22 was described as cumbersome. SRC explained that due to the arrangement of the combustion chamber and the combustion air intake, once charged with peat, the kindling was added, followed by newspaper. With the newspaper ignited from the top, and all access doors closed, the flames were drawn downwards and the kindling subsequently ignited. The procedure worked quite well but required continuous attention during the ignition period.

During the testing, each unit was subjected to firing at high, medium and low output levels. The maximum output levels were determined for each unit (See Table 5-1).

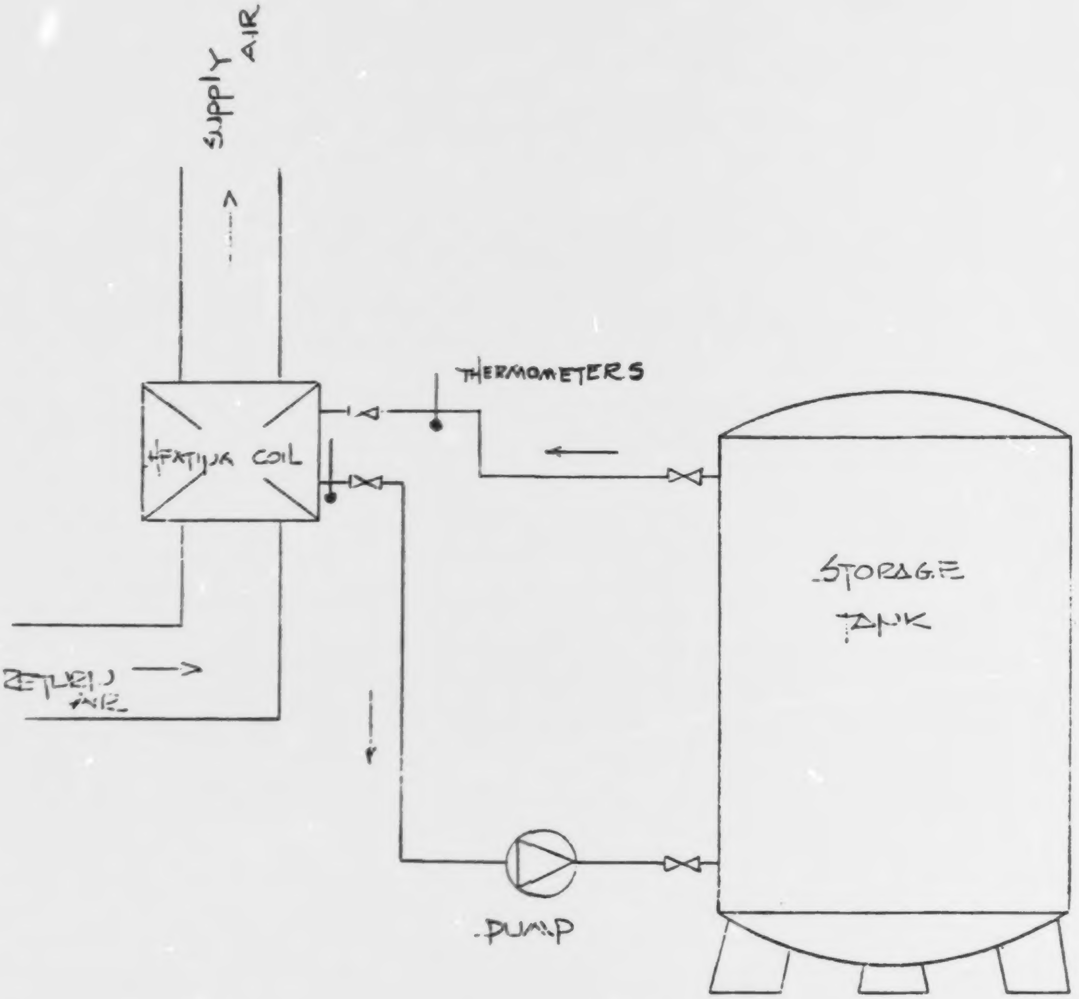

Bypass valve
Pump
STORAGE TANK
BOILER
Control Valve

Source: SMR Report, March, 1982

FIGURE 5-1

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

PIPING SYSTEM AS TESTED


SUPPLY AIR
THERMOMETERS
HEATING COIL
STORAGE TANK
RETURN AIR
PUMP

'A' COIL ≈ 120,000 BTU/HR

FIGURE 5-2

BUFFALO NARROWS FUEL PEAT DEMONSTRATION PROJECT

SYSTEM TO SIMULATE A RESIDENTIAL HEATING LOAD

Source: SMR Report, March, 1982

TABLE 5-3: Maximum Furnace Output

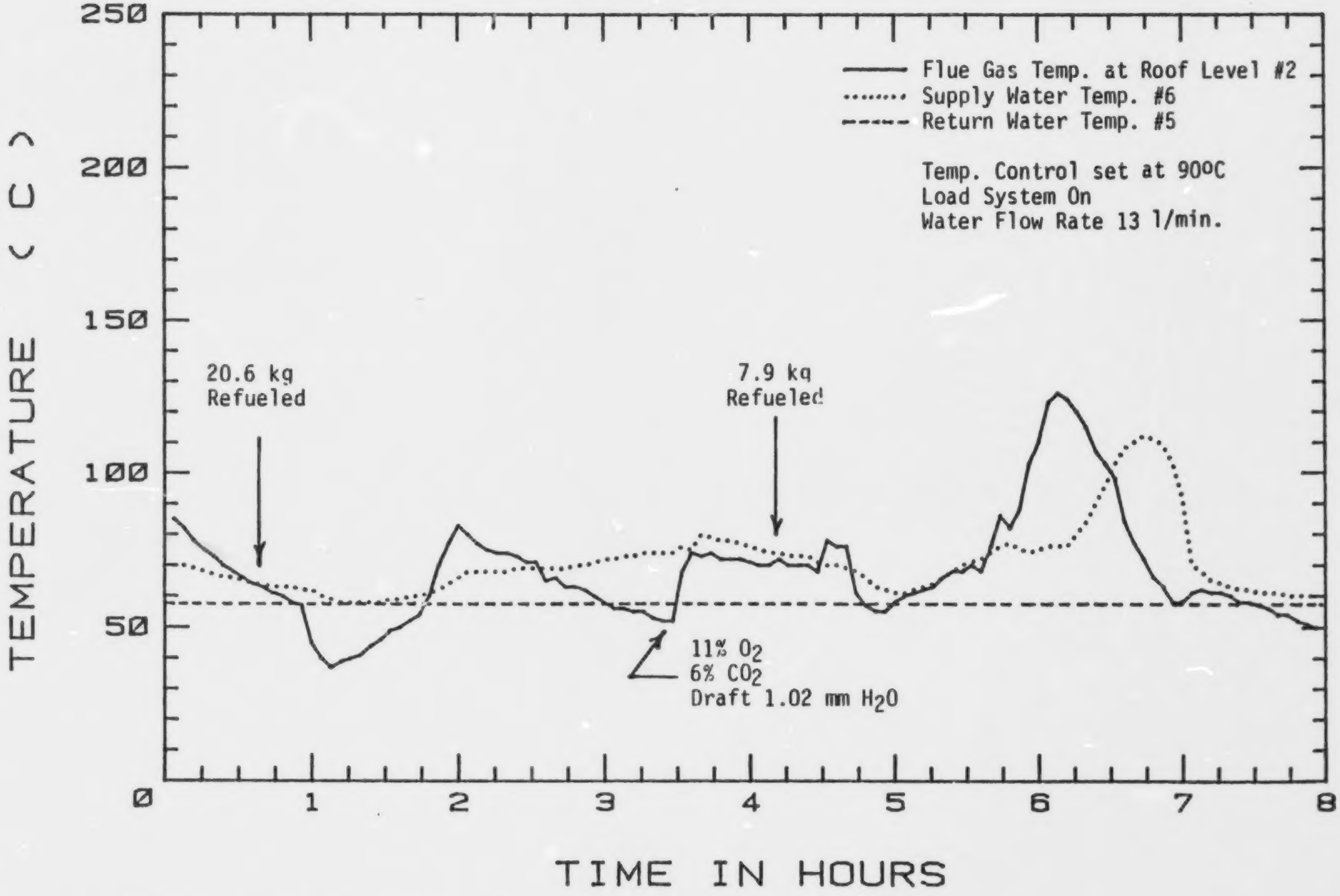
Furnace Unit	Max. Flue Gas Temperature °C	Fuel Gas Analysis		Calculated Max. Power Output (kW)
		% Carbon Dioxide	% Oxygen	
Arimax 25	350	15	3	38.5
Viessmann Mono F	400	16	4	27.3
Hakas TP 22	270	19	2	37

SRC did not note any major problems with the units when operating at these levels. However, this was not entirely the case at medium or low level testing.

It was reported that the Arimax unit performed well at medium output (flue gas temperature of 200°C). When the unit was subsequently operated at a low output level, (flue gas temperature of 150°C) the performance was noted to be poor. Changes in the control setting resulted in only "sluggish" increases or decreases in the flue gas temperature. SRC personnel also found that refueling tended to influence performance. For instance, following the placement of a little over 20 kg of peat into the storage bin, a drop in the flue gas temperature was noted. In fact, the temperature did not exceed 125°C for 4 hours after the placement of the peat in the bin. Even with the damper open, all attempts to increase the rate of combustion failed. Only after 4 hours did this condition correct itself. Figure 5-3 illustrates the impact refueling had on the Arimax 25.

Refueling did not have a pronounced effect on the performance of the Viessmann Mono F. SRC found that following a typical refueling load of 14.2 kg, the flue gas temperature dropped for about 10 minutes and then reverted back. It was noted however, that due to the unit's limited fuel capacity, refueling had to be done approximately every three hours to maintain a useable output and to ensure that enough hot embers remained to ignite the fresh fuel. Although refueling did not

FIGURE 5-3 ARIMAX TEMPERATURE DATA AS A FUNCTION OF TIME



Source: SMR Report, March, 1982

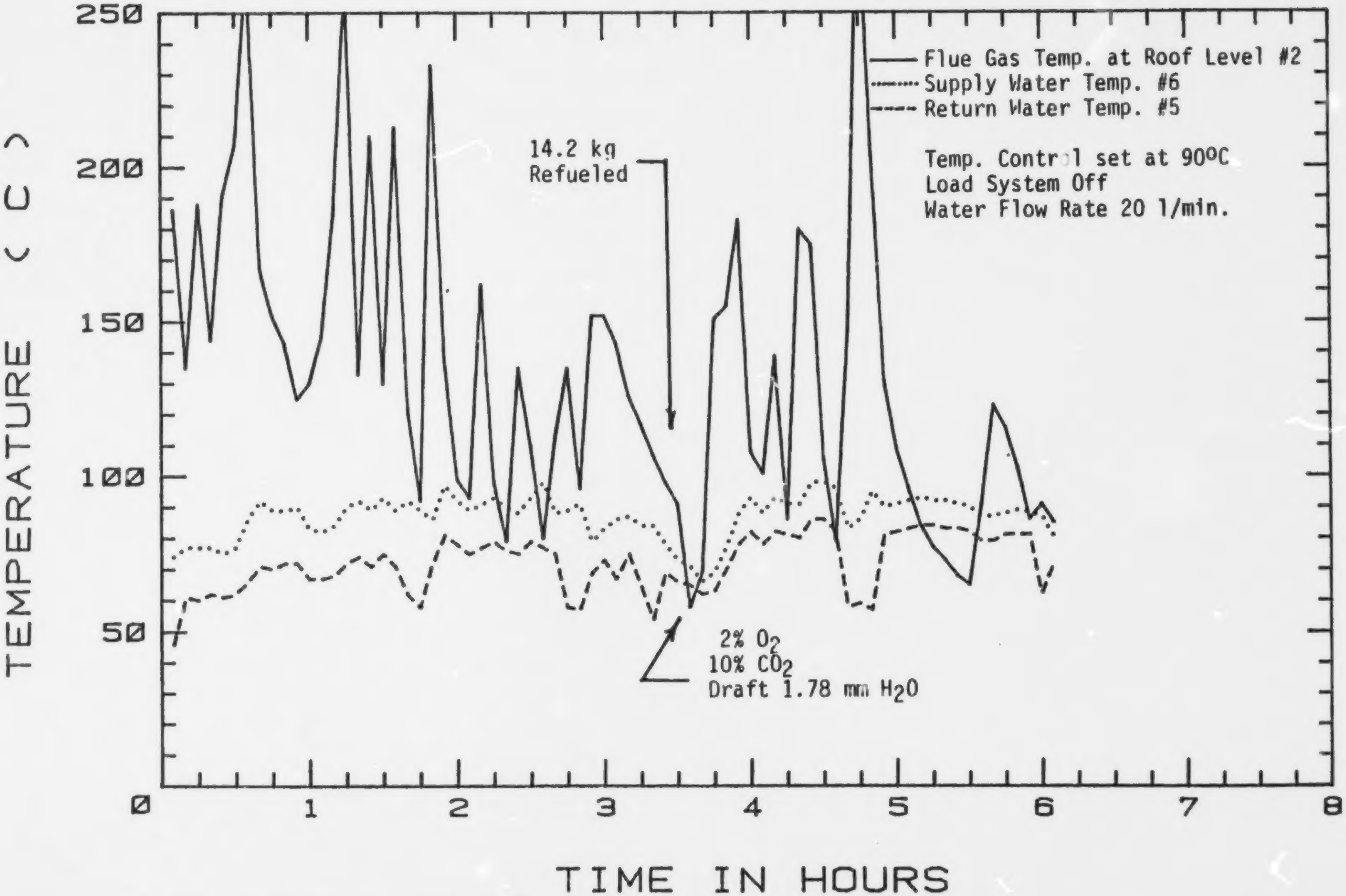
pose any problems, SRC did report that the Viessmann unit experienced a control instability when the supply water temperature reached 89°C. They noted that in this situation the primary air damper was almost closed. The force of the supply air flowing around the damper was sufficient to overcome the action of the control mechanism, which resulted in the damper closing. When this happened, combustion decreased and caused the flue gas temperature to drop. As a direct result of the decreased combustion, the combustion draft decreased. Consequently, the pressure on the damper was lessened allowing it to spring open to the position dictated by the thermostat. SRC noted that this phenomenon persisted until the return water temperature dropped to 55°C, at which point the unit reverted to stable operation at a medium output level, with a steady flue gas temperature of 300°C at the bottom of the flue. This instability is depicted in Figure 5-4. Due to this instability, testing at a low level output was not meaningful.

SRC personnel reported that the Hakas TP 22 worked satisfactorily at medium and low power output, with flue gas temperatures in the range 150°C to 250°C, measured at the unit. The automatic damper control system worked smoothly. The unit responded quickly to manual changes of the dampers, and displayed a steady increase in flue gas temperature up to the maximum of 270°C. The large heat capacity of the water jacket tended to smooth out any irregularities in the combustion process. Refueling did have an effect on the flue gas temperature. It was found that the flue gas temperature dropped following refueling for about 30 minutes whereupon it reverted back. The combustion characteristics of the Hakas furnace are shown in Figure 5-5.

In the course of conducting the test-firing of the furnaces, several observations and other difficulties were mentioned. Besides the problems created by refueling, SRC found that during the loading of fuel into the Arimax unit, large quantities of smoke were being emitted. Also, after a total operating time of 18 hours, all the

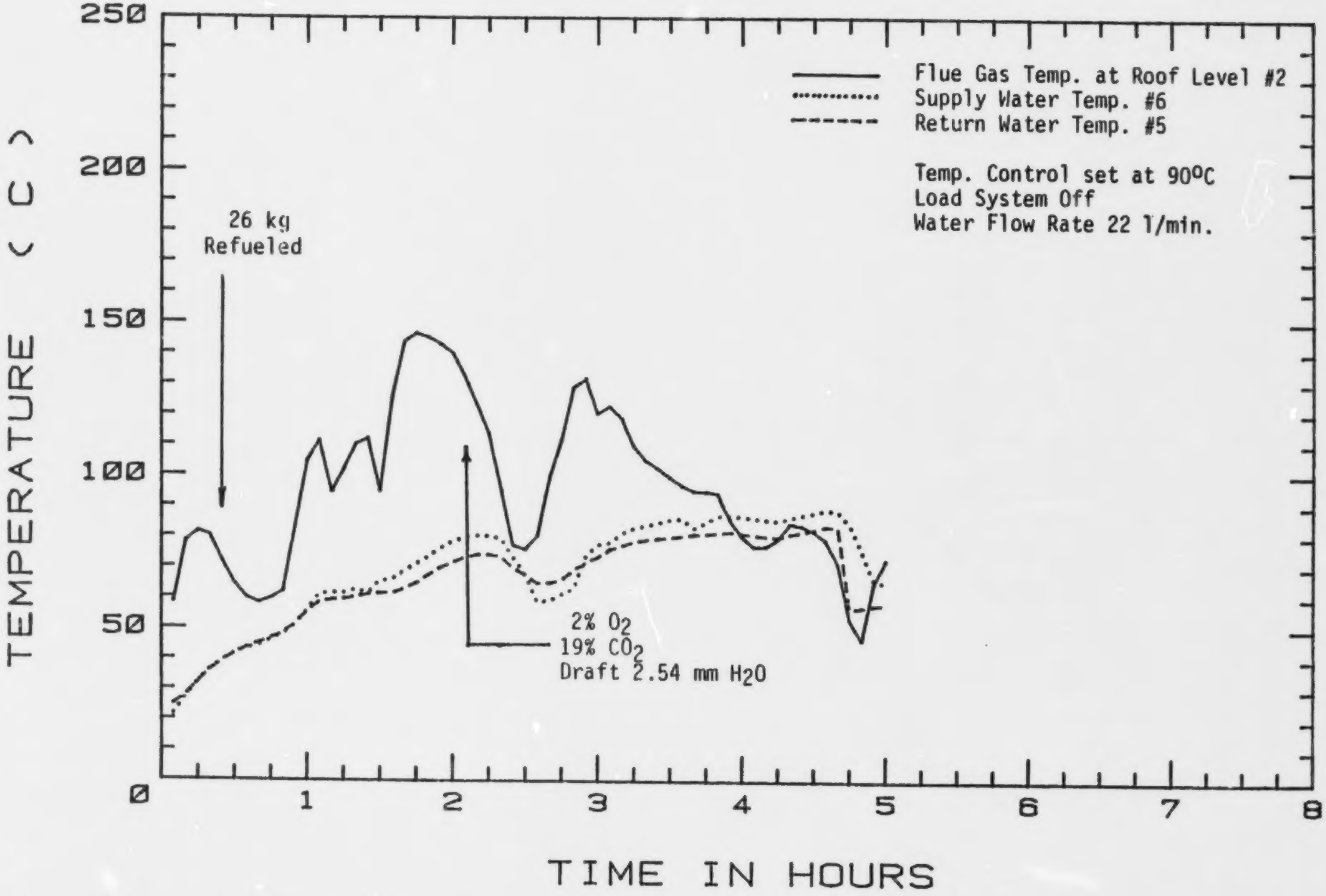
FIGURE 5-4

VIESSMANN TEMPERATURE DATA
AS A FUNCTION OF TIME



Source: SMR Report, March, 1982

FIGURE 5-5 HAKAS TEMPERATURE DATA AS A FUNCTION OF TIME



Source: SMR Report, March, 1982

surfaces within the unit storage area were coated with up to 1.5 mm of creosote, however, the combustion area was clean. The surfaces in the afterburn chamber were covered with a 3 mm deposit of carbon. Also, grate clearing was required every 3 to 5 hours to allow combustion air to pass through the primary air grate. In reference to the Viessmann unit, SRC staff observed that there were no visible deposits of creosote within the furnace. However, the internal surfaces of the flue had a thin coating of carbon. In addition to its ignition problems, the Hakas TP 22 also had problems regarding creosote. It was found that after a total operating time of 20 hours all surfaces in the storage bin were coated with up to 2.5 mm of creosote. The surfaces in the combustion area were clean. The surfaces in the secondary combustion chamber were coated with 2 mm of dry carbon deposit. Also, it was necessary to shake the grate every 3 to 5 hours.

.5 Results

The results of the furnace test-firing are presented in Table 5-2. As can be seen, the average combustion efficiency of the various units ranged from 63.5% for the Arimax furnace to 84% for the Hakas. The effectiveness of the furnace figure, that is, input power versus output power, was greatest for the Hakas furnace, 77.8%, and the least for the Arimax, 54.9%. The largest loss of free heat was recorded for the Viessmann unit, 10.5%. Ash losses in all of the units was around 2.5%. Flue losses of CO were the greatest in the Arimax unit, 19.4%. Losses (heat) due to conduction and radiation were about 6% for all of the units. Overall, the greatest amount of losses were recorded for the Arimax furnace, 37.5% while the Hakas furnace only recorded 22.2% losses.

TABLE 5-4. Summary of the Furnace Test-Firing.

	Arimax	Viessmann	Hakas
Total time of operation	18 hrs.	6 hrs.	9 hrs.
Outdoor temperature	-15.5°C	-18.0°C	-16.0°C
Barometric pressure	732.5 mm Hg	751.2 mm Hg	741.5 mm Hg
Wet bulb indoor temperature	4.5°C	3.2°C	4.3°C
Dry bulb indoor temperature	12.2°C	10.0°C	14.5°C
Moisture content of fuel	30%	30%	30%
Carbon content of fuel (dry basis)	58.2%	58.2%	58.2%
Hydrogen content of fuel (dry basis)	5.5%	5.5%	5.5%
Sulphur & nitrogen content of fuel (dry basis)	2.0%	2.0%	2.0%
Net calorific value	18.2 MJ/kg	18.2 MJ/kg	18.2 MJ/kg
Total dry fuel burned	51.8 kg	33.7 kg	26 kg
Average fuel flow	2.8 kg/hr	5.6 kg/hr	2.9 kg/hr
Average supply water temperature	65.5°C	86°C	73%
Average return water temperature	57°C	73°C	65%
Average flue gas temperature	150°C	200°C	185°C
Average CO_2 content of flue gas	11.6%	15.2%	17%
Average CO content of flue gas	4.9%	4.3%	1.5%
Average O_2 content of flue gas	5.5%	2%	2%
Flow rate of supply water	13 L/min	20 L/min	22 L/min
Flue losses (free heat)	9.5%	10.5%	8.3%
Flue losses CO	19.4%	14.7%	5.2%
Ash losses (Total)	2.6%	2.5%	2.5%
Other losses (conduction, radiation)	6.0%	6.5%	6.2%
Total losses	37.5%	34.2%	22.2%
Combustion efficiency (average)	63.5%	72%	84%
Total effectiveness of furnace	54.9%	65%	77.8%
Average furnace input power	14.1 KW	28.3 KW	14.6 KW
Average furnace output power	7.8 KW	18.2 KW	11.3 KW
Quantity of furnace ash in relation to quantity of peat	10.5%	10%	10%

.6 Conclusions

In reviewing the results of the performacne testing, it would appear that although each furnace had problems of one form or another, overall, each furnace performed adequately when fired on sod peat to have warranted further testing. SRC pointed out that a home in the Buffalo Narrows area had a maximum space heating requirement typically in the range of 20 to 25 KW. Each of the furnaces tested rated above this range during the high output level testing. It must also be remembered that the furnaces were being tested in an industrial building and not in a house and as a result the heating load had to be simulated. Besides this, each unit was operated only for a few hours.

SRC had several concerns regarding the possible danger posed by creosote and by improper fuel loading procedures. Regarding creosote, they felt that low output operation of any of the units would create a creosote build-up. With high flue temperature possible, especially in the Viessmann unit, the risk of flue fires was a matter of concern. SRC also pointed out that improper fuel loading procedures may create a fire hazard. For instance, if the fuel loading hatch were to be opened without first closing the primary air damper, large quantities of soot and combustion gases could be emitted. In some case, they reported, depending on the amount of fuel remaining in the bin, flames could possibly shoot out of the loading hatch to a height of 0.8 m. This problem was noted on the Arimax and Hakas units. SRC emphasized that as a consequence, each homeowner would have to be thoroughly trained to operate the furnace installed in his home.

Although data were obtained regarding the performance of each multi-solid-fuel type furnace, many questions were unanswered, particularly regarding the operation and acceptance of the units by homeowners. The installation of the units in Buffalo Narrows homes and their subsequent monitoring over the planned two year period was expected to answer the remaining questions.

523 HOME HEATING TRIALS AT BUFFALO NARROWS

.1 Introduction

Following the performance testing conducted in Prince Albert, the furnaces were dismantled and transported to Buffalo Narrows for installation in the "test-houses". The installation of the furnaces was performed during the summer and early fall of 1982. Prior to installation, it was decided that the Hakas TP-22 was too bulky and for routine domestic use, and consequently, it was installed in the Buffalo Narrows Municipal Garage, which was felt to be a more appropriate location to take the advantage of its high energy output.

For the purposes of evaluating the performance of the sod peat-fired heating units, it was originally decided that nine houses would be monitored. It was intended that three houses would be totally heated by the sod peat-fired furnaces. This plan was slightly modified later in regard to the Hakas furnace as mentioned earlier. Wood/oil furnaces in two houses were to be converted to peat/oil as well. Finally, four houses with existing fuel-oil furnaces were to be maintained in their existing state and monitored in order to provide data for control purposes.

Since it had been intended to run the furnace performance/home heating trial demonstration over two winter seasons, it was concluded that a simple, less detailed monitoring program would be undertaken during the first year followed by a better controlled monitoring program by well trained operators. It was felt that possible problems (such as handling problems, operating difficulties, technical problems) could arise during testing in the first winter. The plan was therefore to gather less detailed information the first year and concentrate on the mitigation of any shortcomings of the equipment or monitoring methods. The second year was then planned to consists of a comprehensive actual home heating test.

.2 Test Home Selection

Both DNS and SRC took part in the selection of the homes. The selection was made on the basis of the following criteria:

- the homeowner had to be interested in the project and keen to take part in the home heating trials;
- the homeowner had to be well enough instructed to conduct the simple monitoring procedures required;
- for the houses which were to be heated by peat furnances, the homeowners had to be agreeable to the required structural modifications and had to be prepared to operate and monitor these units as instructed;
- for the three houses which were to be heated by peat furnaces, good basement access was needed, as well as adequate basement space for installing the somewhat bulky peat boilers and water storage tanks; and
- for the four "control" houses, the intention was to compensate for climatic effects by observing variations in energy consumption over two or more heating seasons. It was therefore important to have houses with a continuity of occupancy patterns and good access to previous fuel consumption records.

.3 Installation of Furnaces into the Test-Homes

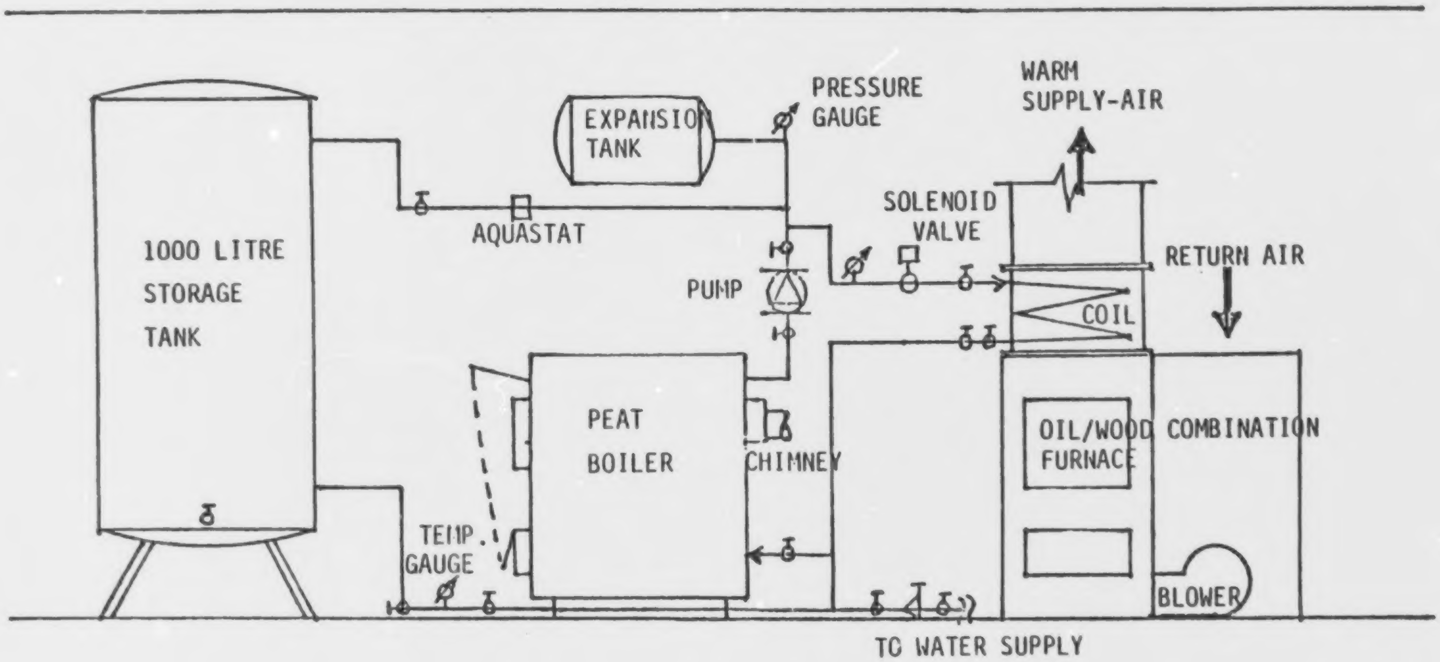
The installation of the furnaces was carried out in 1982. With the Hakas unit being installed in the Buffalo Narrows Municipal Garage, two actual homes were available in which sod peat-fired furnaces were used and could be monitored to gauge their performance in a home heating application. The two houses selected for installation were already equipped with forced-air combination oil-wood furnaces. It was decided to retain these units as auxiliary heaters in the event of failure of the peat boilers. The peat furnaces were coupled with the existing furnace system as illustrated in Figure 5-6.

SRC anticipated that two major problems would be encountered when installing the two domestic peat boiler systems. First, the large thermal storage tanks had a weight of over 1,000 kilograms when full. The basement floors were of wood construction and had to be reinforced to support the weight of the tanks. Secondly, the existing chimneys were found to be too small for the peat furnaces, and it was necessary to install separate chimneys. The peat furnace chimneys, sized to the thermal capacities of the furnace units, were mounted on the outside of the house envelope, with chimney cases matched to the existing exterior finish.

In addition to the aforementioned installations, DNS personnel also replaced the wood grates in two oil-wood units with modified grates for sod peat combustion.

.4 Monitoring Procedures and Instrumentation

As mentioned earlier, the monitoring to be undertaken in the first year was not intended to be very detailed. Enough information was to be gathered so that items such as the theoretical heat loss from a house, the total fuel consumption of a house and the percentage of heating contributed by sod peat could be determined. Further information about the operating parameters of the peat furnaces and the consumer acceptability was also desired.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RETURN AIR
COIL
PEAT
BOILER
CHIMNEY
OIL/WOOD COMBINATION
FURNACE
BLOWER
TEMP.
GAUGE
TO WATER SUPPLY

FIGURE 5-6

BUFFALO NARROWS FUEL PEAT
DEMONSTRATION PROJECT

PEAT FURNACE HEATING SYSTEM

In order to evaluate the performance of the furnaces, several quantities of energy had to be determined. SRC decided to use HOTCAN, (described in the next section) a computer program developed by the National Research Council which calculates the space heating requirements of a house. By determining the heating load, and knowing the actual fuel consumption quantities for a specific home, the performance of a particular heating unit could be evaluated. More specifically, the efficiency of any peat-fired heating unit could generally be determined if the total heating requirement was known as well as how much heat was supplied by other sources (oil) and how much peat had been consumed. In summary, the

$$\begin{array}{l}\text{Overall efficiency}\\ \text{of the peat heating}\\ \text{system}\end{array} = \frac{Qr - Qa \times 100\%}{\text{heat content of peat used}}$$

where: Qr is the total space heating requirement;
Qa is the heat supplied by other sources; and

The monitoring of four homes with oil-fired heating units was intended to serve as a check on the figures generated by the HOTCAN program.

In order to measure certain quantities pertinent to the calculation mentioned above, SRC did the following. Thermocouples were placed at six points in the test houses. As well, scales for weighing the sod peat used were distributed to the homeowners. The homeowners were also supplied log sheets on which to record the quantity of peat they used. Logs were also given to homeowners to keep track of fuel oil purchases. Samples of peat were from time to time tested in the laboratory to check moisture content, calorific value, etc. To measure creosote build up, collection plates were fitted inside the chimney. SRC weighed each plate prior to installation.

.5 HOTCAN

HOTCAN, as previously described, is a computer program that the National Research Council developed for calculating the space heating requirements of a house. To obtain spacing heating requirements figures for a house, information relating to the house such as insulation, window area and orientation, occupancy levels and details of the local climate have to be input. The program then calculates space heating requirements on a monthly basis.

The space heating requirements as calculated by HOTCAN for the home in which the Viessmann furnace was installed and for the two homes in which the grates were changed to accommodate peat burning are shown in Table 5-3.

TABLE 5-5: HOTCAN-Predicted Space Heating Requirements and Corrected Values.

Month	Dec	Jan	Feb	Mar	Apr
HDD, 1951 - 1980	1091	1227	981	852	490
HDD, 1982 - 1983	1051	1098	803	810	*
HDD pro-rating	0.963	0.894	0.819	0.951	1.0*
Viessmann House (kWh/d):					
HOTCAN	93.2	103.7	84.2	59.8	29.5
Corrected	89.8	92.7	68.9	56.9	29.5*
Oil/Peat House #1 (kWh/d):					
HOTCAN	101.4	113.6	97.4	73.0	39.6
Corrected	97.7	101.7	79.7	69.4	39.6*
Oil/Peat House #2 (kWh/d):					
HOTCAN	94.0	104.7	84.5	57.4	25.3
Corrected	90.5	93.7	69.1	54.6	25.3*

HDD: Heating Degree Days

(*The Buffalo Narrows weather office was closed down in April 1983, and no further data was available The corrected values for April are assumed to be the same as the HOTCAN values).

Since the figures generated by HOTCAN were based on long-term average climatic data, SRC updated them by pro-rating the heating requirements according to the heating degree days during the testing period.

.6 Findings

The Hakes TP 22, which had been installed in the Buffalo Narrows Municipal Garage, was fired on peat 64 days during the 94 day monitoring period. The average daily peat consumption was 100 kg. SRC reported that it was not practical to conduct detailed monitoring on this unit because the door of the garage were frequently opened and and closed to allow snow plows and other equipment to enter and exit. Because of this it was very difficut to model this building using the HOTCAN computer program.

The Arimax unit was in operation for only a short time. The homeowner complained of excessive dust levels inside the house and withdrew from the program regardless of the negotiations. SRC was not certain about the reason for the excessive dust levels.

The only peat furnace that was monitored in residential use for any significant length of time was the Viessmann Mono F. The monitoring period was 113 days of which peat was used for 83 days. The average daily consmuption of peat was 55 kg. The unit required refueling every 4 hours. SRC noted that the homeowner reported no serious problems with fuel loading and ash cleaning and stated that it operated like a wood stove.

In the two homes where the grates in multi-fuel furnaces had been repleaced to accommodate peat burning, in house #1, peat was used 44 of 135 days. On average, 29 kg. of peat were consumed. Refueling was required every 3 hours. In house #2, peat was used 83 out of 111 days. Daily consumption averaged 34 kg. Refueling was required every 2.5 hours.

With regard to creosote and soot build-up SRC noted that the Hakas unit had a light to moderate build-up. The accumulation in the Viessmann unit was moderate. In the two oil/peat units, creosote and soot build-up were light. SRC noted that the moderate build-up warranted a cleaning at least once every heating season.

During the testing, homeowners complained of dust and fly ash problems. The owner of the home in which the Viessmann unit had been installed noted that a peat odor somewhat similar to a tobacco odor lingered in the house. A distinct peat odor was also noticed outside the house during peat firing, however, it did not appear to be offensive to the neighbours.

The homeowners of the two oil/peat units noted that their homes overheated during mild winter conditions necessitating the opening of windows and doors. Large temperature swings in living areas of these homes were recorded during firing on peat. The house temperature were much more uniform during oil-fired operation. SRC reported that large temperature swings were not observed in Viessmann house except in the immediate area of the furnace. The reasons for this remained unclear.

The only other problem noted by homeowners with some consistency regarded the bags in which the Finnish peat had been packaged. The complaint was that they were too heavy to handle at 39 kg each.

.7 Results

The performance results of the furnace testing are given in Table 5-6.

TABLE 5-6. Estimated Efficiency of the Peat-Fired Units.

House	Total space heat in period (est) (kWh)	Heat output of oil mode (kWh)	Estimated heat from peat (kWh)	Total cal. value of peat burnt (kWh)	Estimated Seasonal Efficiency (%)
Viessmann	8213	4200	4013	22326	17.8
Oil/peat #1	11526	5761	5765	6112	94.3
Oil/peat #2	7976	4900	3076	13798	22.2

As can be seen in Table 5-6, the efficiency of the Viessmann furnace during the home heating trials was 17.8%. The efficiency for the oil/peat unit in house #2 was not much better at 22.2%. Conversely, the unit in house #1 recorded an efficiency of 94.3%. These figures are somewhat distorted and should be viewed with the following in mind. In Table 5-7, the amount of peat delivered and burned in each household is given. As can be seen, some sizeable discrepancies exist between the amount of peat delivered to a test home and the amount that was burned, especially for house #1. Also, due to a misunderstanding, oil consumption figures were not properly recorded by homeowners in the houses used for control purposes. Consequently, the check against the space heating requirement figure generated for each test-home by the HOTCAN computer program was not available.

The efficiency figures can be viewed as preliminary at best.

TABLE 5-7. Comparison of Amounts of Peat Delivered and Burnt.

	Hakas Garage	Viessmann	Oil/peat #1	Oil/peat #2	Overall Consumption
Total amount of peat delivered as recorded kg	149 bags 5757	137 bags 5293	49 bags 1893	87 bags 3361	422 bags 16304
Non-used portion kg	191	521	77	464	1253
Homeowner's record of consumption kg	6456	4613	1263	2851	15183
Discrepancy kg *	+891	-160	-553	-46	+132
$\frac{\text{Discrepancy}}{\text{Amount delivered}}$ %	+15.5	-3.0	-29.2	-1.4	+0.8

* Discrepancy is positive when homeowners record and quantity exceeds that delivered.

The results of the home heating finds were generally not impressive. A number of problems were encountered. Some of them were anticipated and because of this, the first heating season was be intended to be a "break-in" period, a period in which to remedy both expected and unexpected problems so that the monitoring program during the second year would run smoothly. Consequently, less emphasis was placed on monitoring precision. Some of the anticipated problems were of a technical nature such as connecting of the imported furnaces to the Canadian standard equipment, installing these imported hydronic units to forced air heating systems, installing heavy (1 tonne and more) reservoir tanks in the basements of the test homes, constructing proper flues and chinmeys, proper handling of the fuel peat, training the homeowners to monitor the trials properly and winning the consumer's acceptance. The last item was the most difficult to control because of the human factor involved. It was anticipated that the basic problem in the consumer acceptance of the heating units would be the physical effort needed to operate a solid fuel furnace in contrast to the comfort of a fully automatic oil-fired furnace.

The selected homeowners intially accepted the challenge. However, one of them abruptly withdrew from the project for unknown reasons leaving one of the furnace units out of the trials (Arimax).

The other units did function reasonably well. As the results in the Tables 5-6 and 5-7 indicate there is quite a wide discrepancy in the efficiency values and fuel consumption/delivery figures. The reason for these are partly unclear. It is only suspected at this stage that partly these are due to problems in the installation and monitoring system and mostly due to the human factor involved in the monitoring of the fuel consumption and the proper control of the furnaces. The discrepancies are not considered unanswered inasmuch the first season really was to be used to eliminate the problems. It is believed that the second season of heating would have afforded time for the consumer's assessment of the use of peat as a fuel.

The data also indicated that the sod peat burned inefficiently in these heating units. However, these units are in common use in Europe and perform well and plus, it is believed that since the problems had been sorted out during the first heating season the proper efficiencies would have neen reached during the second season.

PART 6

PROJECT COSTS

PART 6 - PROJECT COSTS

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6.0 ANALYSIS OF DEMONSTRATION PROJECT COSTS

6.1 INTRODUCTION

In this section, the costs of the various phases of the demonstration project are outlined. In particular, the costs associated with preparing and producing sod peat from the selected peatland have been compiled as well as the costs incurred during various stages of the furnace testing/home heating evaluation phase of the project.

It is emphasized that the costs which are presented reflect those associated with a demonstration project and not a commercial operation. The previous statement is particularly applicable to the cost figures pertaining to peatland preparation and sod peat production. For instance, if sod peat production were considered on a commercial scale, most of the equipment required for the day-to-day operations would be purchased rather than rented as was done during the demonstration project. Many of the demonstration costs contain a considerable component of transportation charges which would not be included in a commercial operation. For example, for a commercial sod peat production operation, once the equipment is on site, there would be no reason other than for a major repair to haul it back to the dealer. However, with all of the major equipment items being rented for the demonstration project, various machines, such as the Dondi ditcher were hauled back and forth to the site on an as required basis. The haulage costs from Carrot River to Buffalo Narrows and return actually exceeded the rental cost.

The summary of project costs reflects the costs incurred in developing a very small peatland (actually only a few hectares). Consequently, the unit costs associated ($/ha) with certain activities are quite high. For instance, the costs of developing a mine plan and selecting a mining method for the peatland were $5200. When the cost is expressed on a per hectare basis, the resulting figure is $130/ha. However, if the bog chosen for the demonstration project had been 80 ha, mine plan development and mining method selection costs would not have been significantly higher, and consequently the unit cost would have been considerably lower, about $65/ha.

Due to budget constraints and the limited objectives of the project, the costs associated with this project cannot be taken to be representative of a larger commercial operation. However, for someone unfamiliar with peatland development, the information may be useful to give an order-of-magnitude estimate of costs associated at least with the initial stages of a small peatland development undertaking.

The bog survey was carried out in an earlier program prior to the demonstration project but the costs have been included since they represent a portion of the normal costs of developing a peatland.

6.2 BOG SURVEY COSTS

The bog survey costs include only the costs actually incurred in the survey of the demonstration bog and exclude costs leading to the selection of the specific site, since they vary considerably from location to location. Factors such as location, access, the need for a helicopter, prior information on the resource, etc., result in the site selection costs being too variable to be included as representative of a predictable cost item.

The bog survey costs carried out prior to the start-up of the demonstration project, can be fairly accurately determined since the survey method usually follows standardized methods repeated in more or less the same manner at each individual site. The main difference in the cost per hectare surveyed is dictated by the size of the deposit to be investigated. The unit cost given, therefore, has to be treated as a guideline only applicable to small deposits. With an increase in the size of the deposit surveyed, the unit price usually decreases.

The bog survey costs include office engineering costs such as the examination of air photos and maps in preparation for the field work and a selection of a number of sites to be visited. This is followed by the actual field survey including the costs of the field personnel, out-of-pocket expenses, office support staff costs (drafting, etc.), and later further office engineering costs to prepare the report and the costs for laboratory analysis of samples. The total cost of the bog survey was about $10,850. The total area of the bog was 40 ha, giving a unit cost for survey work at about $270/ha, somewhat high. However, the cost includes the entire report, costs of the peat analyses and all the necessary calculations on the size and quality of the resource. The percentage of reporting, in the case of a small deposit, is a considerable portion is a considerable portion of the total cost and increases the unit cost. In this case, the reporting and other activities excluding the fieldwork, were 60% of the total cost. However, in a survey involving a large deposit, reporting costs would be considerably lower, and it is expected the unit cost would be less tha 50% of the amount shown. Of course, this depends on the survey detail required and the cost of the analytical work which can increase the costs considerably in the case of heterogeneous deposits.

The survey costs do not include any costs for detailed peat thickness measurements or levelling costs incurred immediately prior to the establishment of the actual operation. These costs are included in the pre-preparation phase costs and are discussed later.

6.3 BOG PREPARATION COSTS

631 MINE PLAN DEVELOPMENT AND MINING METHOD SELECTION COSTS

The total engineering cost, for the development of a mine plan for the demonstration bog was about $5,300. Included are the costs associated with devising the field drainage pattern, selecting the location of both the access road and storage compound, and the mining method selection costs. The mining method selection costs are included since they are an integral part of the development of the mining plan. The costs include manhours for professionals and technicians involved from time to time in the work. The costs could be considerably higher for a large commercial operation since more time consuming drainage and field layout planning would be involved as well as considerable more drafting. The costs can also be expressed on a $/ha basis, although this may not always be meaningful since the unit cost depends on the uniformity of the bog and on the drainability of the total area. Usually, the unit cost is lower for a larger area, however, in the case of the demonstration bog, the cost was about $130/ha.

632 MISCELLANEOUS COSTS

There are costs not directly involved in the mining plan and method selection, in addition to the direct planning costs. The major item was the cost of carrying out a climatic analysis to determine the climatic suitability of the specific location for peat mining. The analysis is needed especially when selecting the mining method, since the various methods are affected by the climate in different ways (such as output) and in some cases, certain climatic conditions might exclude a specific mining method. In the case of the Buffalo Narrows region, this was important because of its proximity to the permafrost zone. The total engineering effort to carry out the basic climatic analysis in this case was about $1700, which when added to the mining plan and method selection cost, makes a total of about $7000 or $185/ha. In the case of a large peat deposit, the climatic analysis cost would be a relatively insignificant fraction of the total mine planning and method selection costs.

6.4 EQUIPMENT SELECTION AND PROCUREMENT COSTS

The equipment fleet required to prepare a peatland for production is composed partly of machinery used only for pre-production activities as well as equipment that can be used for both pre-production and production activities. However, since some of the major machinery such as the tractors are used both in pre-production and the production phase and since certain pieces of equipment such as, e.g. the rotovator, will are used later in pre-production activities for area expansion, all the equipment costs covering both preparation and peat production phases are included here.

The selection of equipment for the pre-production phase entailed assembling and pricing a complete equipment list. After final selection, information was gathered about the price of each piece of equipment. Following an analysis of performance ratings, monthly rental rate quotations were requested on certain pieces of equipment. On the basis of a number of selection criteria such as cost, availability, proximity of a dealership to the site, etc., a final selection was made. The total office "engineering" cost for this phase of the project was about $3550. The costs of shipping and receiving the actual pieces of the machinery are included in the operating cost accounts. No significant equipment purchases were made for the project and thus, no capital costs were incurred. Some small tools were purchased and their costs were included in the equipment maintenance and operating costs.

6.5 PRE-PRODUCTION COSTS

Separate costs have been calculated for each of the various pre-production phases. For each phase, including drainage, tree removal, brush cutting, rotovating and screw profiling, the costs have been subdivided into labour, equipment maintenance and operating, expenses, rental, freight and miscellaneous costs whenever possible. The costs have been summarized in Table 6-1.

651 DRAINAGE

All drainage costs incurred before the "start-up of production" are included. This covers costs incurred during the first drainage pass in December, 1981 to open the field ditches, the preparation of the ends of the field ditches by the excvator/backhoe, later re-cutting of the field ditches,the deepening and cleaning of the western perimeter ditch by a locally rented backhoe in July, 1982 and the manual ditch cleaning. The total expenses for all the above steps was about $45,000.

TABLE 6-1

Pre-Production Costs

Cost Sumamry of the Actual Demonstration Project

TASK	TOTAL	ENGINEERING CHARGES	LABOUR	EQUIPMENT RENTAL AND FREIGHT	FUEL, SUPPLIES AND MISCELLANEOUS REPAIRS
Bog Survey	10,850	10,850	--	--	--
Mine Plan Development and Mining Method Selection	7,000	7,000	--	--	--
Equipment Selection and Procurement	3,550	3,550	--	--	--
PRE-PRODUCTION					
Drainage	44,925	15,000	6,700	23,000	225
Yard and Access Construction	8,050	1,700	1,150	3,550	1,650
Tree Removal	30,000	11,500	9,400	7,700	1,400
Brush Cutting	2,900	1,100	550	850	400
Rotovating	4,600	1,100	450	3,000	50
Screw Profiling	17,650	7,200	2,600	7,630	220
Total Pre-Production Costs:	$129,525				
Total Actual Pre-Production Bog Work (1)	$108,125				

The total can be divided into items such as supervision costs (including time charges and out-of-pocket expenses) of $15,000, labour costs of $6,700, equipment rental plus freight costs of $23,000, miscellaneous maintenance, repair and fuel and other minor expenses of $225.

The labour costs included DNS camp accommodation for all personnel who visited the site as well as the manual clearing of the ditches. The bridge construction costs have been included into yard and access construction costs. The costs of renting a Ford 6600 tractor for the entire season has been listed as a separate item, although later it was used to a minor degree to help in the construction of the yard and the bridges.

Some costs are not included, since back-up information was not available from the Department of Northern Saskatchewan such as:

- the labour costs for three men hired for about one week from Carrot River Peat Moss Company to carry out field ditching in November, 1981;
- the freight costs of the Kopo ditcher,(Montreal - Prince Albert return).

The unit costs ($/ha) of drainage ditching are high, about $11,200/ha, since only two fields were prepared although the whole bog (25 ha) was perimeter ditched. The unit cost cannot be considered meaningful in this case.

652 YARD AND ACCESS CONSTRUCTION

These costs represent the cost of constructing the access road, equipment yard and the bridges over the perimeter and field ditches. DNS equipment and personnel were utilized for this part of the work. The total cost including both the DNS costs (manpower, equipment, materials) and engineering supervision costs were $8050. This can be subdivided into engineering costs of $1700, materials $1650 (culverts-$250, gravel-$1400), and DNS equipment rental and labour which amounted to $3,550 and $1,150 respectively.

653 TREE REMOVAL

Tree removal operations consisted of pulling the trees on the bog and transporting them off the bog to a suitable site. The trees were transported to the western edge of the bog, about 100 metres north of the yard, in order to minimize the transport costs. The total tree removal cost including supervision costs, labour costs and the equipment rental and freight costs were approximately $30,000.

The supervision costs (including peat specialist) were about $11,500, labour costs $9,400 and the equipment rental and freight costs $7,700. About $400 was used to buy minor pieces of equipment such as chains, etc. Equipment maintenance, fuel and repair costs were approximately $1,000.

Unit area costs were about $15,000/hectare. The tree removal cost depends very much on the density of the tree, cover size of trees, transport distance, and area covered.

654 BRUSH CUTTING

Brush cutting costs included fuel and machine repair costs ($400), equipment rental and freight, labour($550) and engineering supervision costs ($1100) amounting to a total of about $2900. This can be expressed as a unit cost of about $1450/hectare which is high compared with a commercial operation cost. For a larger area a lowering of costs would occur in the rental and freight cost portions.

655 ROTOVATING

The rotovating operation is similar to brush cutting in a technical sense and the time and effort required is also similar with the costs differing mainly due to the rental rates. The total cost of $4600 to rotovate the demonstration site consisted of equipment rental and freight costs ($3000), labour costs ($450), supervision charges ($1100) and operating expenses ($50).

Unit area costs for rotovating was $2300/ha. The cost would be considerably lower for large sized operations for which the rotovator would be bought and amortized over a number of years.

656 SCREW PROFILING

To produce sod peat, the surficial moss peat layer had to be removed. This was accomplished by using a screw profiler. The total cost of this portion of the pre-production phase was approximately $17,650. Included are the supervision costs ($7200), labour costs ($2600), equipment (screw profiler, tractor) rental and freight costs ($7630) and operating (fuel) costs ($220). The cost per hectare was about $8800. This figure, too, is relatively high as compared with a large commercial operation for which the profiler would be bought and amortized over a number of years.

6.6 SOD PRODUCTION AND STORAGE

The cost of cutting, collecting, and hauling sods from the demonstration bog to the DNS depot for storage was $11,050 (see Table 6-2). Out of the $11,050, $5,950 were costs associated with sod cutting, specifically supervision ($2,300), labour ($350) and equipment rental, and freight costs ($3280) and fuel ($20). The remaining $5,100 represents the cost of collecting and hauling the sods from the bog to depot. The cost can be broken down into the following components: supervision ($2,500), labour ($2,050), tractor, and trailer rental ($450) and fuel, supplies and miscellaneous repairs ($100). Approximately 8 tonnes of the sods were produced, costing about $1,381/tonne. The unit cost shown here is not meaningful and does not represent unit costs of sod peat produced under industrial scale conditions. The 8 tonnes of sods were harvested manually and represented only an attempt to obtain some sod peat during the first year of drainage, for testing purposes.

Unfortunately, although it was intended to operate a full production cycle the following season (1983 summer), it was not possible due to a cut in the project budget.

6.7 DRAINAGE CLEARING (MAINTENANCE)

To ensure good drainage for the year 1983, all the field ditches were cleared with a Dondi ditcher after the first attempt to produce sods and after the screw profiling step. These costs include the engineering supervision costs ($1500), the equipment (trailer and ditcher) rental, freight, fuel costs and labour costs ($5700), bringing the total to $7200. Before the drainage was done, a thorough survey of the surface elevations along all the ditches was carried out. The cost of this work ($5500) consisting of engineering costs is

TABLE 6-2

Cost Summary Of The Actual Demonstration Project

Production Costs

TASK	TOTAL	ENGINEERING CHARGES	LABOUR	EQUIPMENT RENTAL AND FREIGHT	FUEL, SUPPLIES AND MISCELLANEOUS REPAIRS
Sod Cutting	5,950	2,300	350	3,280	20
Sod Hauling	5,100	2,500	2,050	450	100
Drainage/Clearing	7,200	1,500		5,700	
Levelling	5,500	5,500			
Total Production Phase:	$23,750				

Note: Although about 8 tonnes of sod peat produced and collected manually in an attempt to obtain some peat for testing purposes, the 1982 season was scheduled for drainage and surface preparation activities and hence sod production costs shown above are not typical of an operation situation and are included for general interest only.

to be added to the costs of the drainage clearing to bring the total drainage maintenance costs up to $12,700; again a high cost reflecting the demonstration nature of the project.

6.8 COST SUMMARY

Table 6-3 summarizes the cost of conducting the sod peat mining demonstration. The estimated costs of a full production cycle (which was to have been conducted during the summer of 1983) and the 5000 tonne per year commercial sod peat operation have also been included.

Table 6-3 shows the costs per hactare and per tonne greatly inflated in the case of the demonstration project. Only two fields were prepared (2ha) for production and 8 tonnes produced so the unit cost per pre-production or production activities are high. However, due to the discontinuation of the project after the first year, all of the pre-production and production costs have been lumped into one year's cost resuting in a first year as well as a cost per tonne of sod peat produced which only reflects what was actually expended during this short demonstration phase. These figures are further inflated in that full production capacity of e.g. 150 tonnes/ha was not achieved due to the early termination of the project.
These costs, however, far exceed the costs of a commercial operation in which the high initial pre-production costs and capital out-lay are spread over a number of years and large quantities of peat produced.

To illustrate the effect of the costs over a number of years and over a standard yearly production quantity, the unit costs of engineering service for the first year of the demonstration project versus the first year of a commercial project are compared. In the former,the cost per tonne of sod peat produced was $7375 (only

TABLE 6-3: Sod Peat Mining Cost Summary - Buffalo Narrows Fuel Peat Demonstration Project
(Actuals Compared with Estimated)

DEMONSTRATION PROJECT ACTUAL COSTS ($1982)(1)				DEMONSTRATION PROJECT ESTIMATED COSTS TO CARRY OUT FULL PRODUCTION CYCLE ($1983)(2)				ESTIMATED COSTS FOR A COMMERCIAL SOD PEAT OPERATION (5000 Tonnes/Year Sod Peat, 1983$)(3)			
	Cost	Cost/ha(4)	Cost/tonne(5)		Cost	Cost/ha(4)	Cost/tonne(5)		Equiv.Ann. Cost	Equiv.Ann. Cost/ha.	Equiv.Ann. Cost/tonne
PRE-PRODUCTION				**PRE-PRODUCTION**				**PRE-PRODUCTION**			
Eng. Serv.	59000	17270	7375	Eng. Serv.	N.A.	N.A.	N.A.	Eng. Serv.	8700	153	1.74
Working Capital	N.A.	N.A.	N.A.	Working Capital	N.A.	N.A.	N.A.	Working Capital	1900	33	0.38
Equipment Rentals	34830	17415	4354	Equipment Rentals	N.A.	N.A.	N.A.	Equipment Rentals	17200	302	3.44
Fuel, Maint. Supplies & Frgt.	14620	7310	1828	Fuel, Maint. Supplies & Frgt.	N.A.	N.A.	N.A.	Fuel, Maint. Supplies & Frgt.	4400	77	0.88
Labour Services	20850	10425	2606	Labour Services	N.A.	N.A.	N.A.	Labour Services	35400	621	7.08
Facilities	1650	825	206	Facilities	N.A.	N.A.	N.A.	Facilities	28800	505	5.76
PRODUCTION				**PRODUCTION**				**PRODUCTION**			
Engineering Services	11800	5900	1475	Engineering Services	20190	10095	101	Supervision	34000	597	6.80
Production Equipment(7) Rentals	9430	4715	1180	Production Equipment(7) Rentals	30150	15075	151	Production Equipment(8)	50300	882	10.06
Labour	2400	1200	300	Labour	20240	10120	101	Labour	50000	877	10.00
Equipment Maintenance and Servicing	120	60	15	Equipment Maintenance and Servicing	1000	500	5	Equipment Maintenance and Servicing	28400	498	5.68
Miscellaneous	-	-	-	Miscellaneous	-	-	-	Miscellaneous	12000	211	2.40

NOTES:

(1) Actual costs are for the incomplete demonstration project.

(2) Estimated costs for a full-cycle of sod peat production. They should only be used as a guide for estimating costs for a small scale demonstration project of a similar nature in remote areas.

(3) Estimated first year costs for a small scale commercial sod peat production operation. The cost of capital is 12%.

(4) The effective mining area is 2 ha. The cost of all the engineering services on a per hectare basis were spread to cover the entire drainage area encompassed by the perimeter ditch.

(5) Based on 8 tonnes of actual production during the first season.

(6) Based on 200 tonnes of production estimated as an obtainable yield.

(7) Freight included.

(8) Freight not included.

8 tonnes were produced) in contrast to $2.59/tonne for 5000 tonnes of sod peat production. The other unit cost items are smilarly affected by the scale of the commercial operation. The costs of the unfinished demonstration project are shown to not reflect the costs of the actual commercial project. If the project had been run for full production cycle, a more accurate estimate of peat production costs may have been obtained for the production of sod peat at the Buffalo Narrows, Sask. location.

6.9 FURNACE SELECTION, TESTING AND HOME HEATING DEMONSTRATION COST SUMMARY

The costs associated with the selection, testing of the furnaces and the home heating demonstration are presented in this section. The costs have been summarized under the following headings.

691 FURNACE COSTS

Two Finnish multi-solid-fuel furnaces were purchased for the project. The F.O.B. Montreal price of the Arimax 25 and Hakas-TP-22 (furnace, water tank, fuel feeder and necessary attachments, etc.) were $1150 and $10,300 respectively. In addition, a Viessmann Mono F multi-solid-fuel type furnace was supplied free of charge for the project by the manufacturer. During both the performance testing of the furnaces in Prince Albert and the actual installation of the units in the test homes, in Buffalo Narrows, numerous additional parts and supplies were required to what had been sent from the respective factories costing an additional $11,600.

TABLE 6-4. Summary of Costs Associated with Furnace Testing and Installation.

	Cost
Furnaces	$11,400
Furnace Parts and Appurtenances	11,650
Labour	18,000
Travel Expenses (for technicians installing furnaces)	850
Freight	2,500
Total	$44,400

Labour charges for the performance testing and home installation of the various units amounted to $18,000. The cost of meals and accommodations at the DNS camp in Buffalo Narrows for the labourers installing the equipment in the test-homes was $850.

Considerable freight charges were incurred. To haul the Hakas and Arimax furnaces from Montreal to Prince Albert cost $930 and to haul the Viessmann furnace from Waterloo, Ontario to Prince Albert cost $130. Following the performance testing in Prince Albert, the furnaces were shipped to Buffalo Narrows at a cost of $420. Additional freight charges to transport parts to Prince Albert and Buffalo Narrows were $540 and $500 respectively.

692 FINNISH SOD PEAT

Twenty tonnes of Finnish sod peat were purchased for the performance testing of the furnaces and to augment the peat supply for the home heating demonstration phase. The peat cost $8000, and the cost of shipping from Finland to Saskatchewan was $3375. This peat was then packaged in large plastic bags for distribution to the test-homes. The cost of the bags and bagging the peat (labour) was $360 and $2,090, respectively. Several freight charges were incurred as well. A crane costing $290 was used to unload the container in Prince Albert. To handle the bagged peat in Buffalo Narrows cost $280. The cost of transporting the bagged peat to Buffalo Narrows by truck was $1130.

693 TEST HOME SELECTION

In the course of selecting the test-homes, three trips were made by DNS and SRC personnel between Prince Albert and Buffalo Narrows. The aircharters totalled $2070.

694 ENGINEERING SERVICES

The cost of engineering services for this phase of the demonstration project was $13,025. Additional costs of $24,000 was incurred by the Saskatchewan Research Council to monitor the performance of the furnaces during the 1982/83 heating season.

TABLE 6-5. Costs of Purchasing and Handling Finnish Sod Peat.

	Cost
Sod Peat (20 tonnes)	$8,000
Plastic Bags	300
Freight	5,200
Labour (bagging the peat)	2,100
	====
Total	$15,600

TABLE 6-6. Cost Summary for the Furnace Selection/Performance Testing and Home Heating Demonstration Phase

	Cost
Furnaces	$44,500
Finnish Sod Peat	15,500
Engineering Services	13,000
SRC Subcontract	24,000
Test-Home Selection	2,067
	======
	Total$99,000

PART 7

ALTERNATIVE PEAT PRODUCTS AND ENERGY OPTIONS

PART 7 - ALTERNATIVE PEAT PRODUCTS AND ENERGY OPTIONS

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7.0 ALTERNATIVE PEAT PRODUCTS AND ENERGY OPTIONS

7.1 INTRODUCTION

In the past, peat has been used, on there have been attempts to use it, for the production of a variety of products including activated carbon, coke, waxes and a host of chemicals. Many of the uses never proved to be commercially viable and the interest waned in with the introduction of readily available petroleum products. Only the use of peat as a direct-fired fuel, and at a smaller scale, in the production of coke and activated carbon have survived. However, recently there has been a increased interest in peat again a source of refined products. Research into peat as a source of coke, etc., has been quite active in West Germany, the U.K., the Netherlands, Ireland, Finland, the U.S.S.R. and recently also in Canada and the United States.

Considering the large peat resources and the good quality of peat in Saskatchewan a brief account of the potential of producing peat coke and activated carbon from peat is included. Also some comments on district heating are given due to its potential use in northern Saskatchewan as an alternative for individual home heating system in general, and for the demonstration area in specific.

7.2 PEAT COKE

In Europe, peat coke is used in applications where a highly reactive, low-sulphur metallurgical coke is required. While peat, due to its low sulphur content and high reactivity is an excellent source material for this purpose it will not produce coke hard enough to be useable in blast furnace. However, peat coke has been found to be suitable as a metallurgical coke for use in electric furnaces, where hardness and abrasion resistance are not critical, as well as in the case hardening of steels - carborizing. In addition to these potential uses, it can also be used in the chemical industry as a reducing agent. Table 7-1 lists the main potential uses, for peat coke and the potential market based on present annual consumption trends of various types of coke.

TABLE 7-1

Types of Coke With Replacement Potential for Peat Coke in Canada.

Potential Use	Potential Market (tonnes/year)
Metallurgical Coke/ Electric Furnaces	50,000 to 90,000
Case Hardening of Steels - "Carborizing"	very little
Reducing Agent/ Chemical Industry	170,000 to 280,000

Peat coke would have to compete with petroleum cokes and screened coal coke not suitable for blast furnace operators. These two materials are heavily price discounted as they are both by-products. Monenco estimates of peat coke production costs ($220 - $400/tonne) indicate that peat coke would be at least four times more expensive than these materials. Consequently, this does not appear to be a viable market at this time.

The cost of peat coke is sensitive to the coking operation plant size, reducing considerably at larger scale production levels. The peat mining cost also influences the costs of coke production.

To produce 15,000 tonnes of peat coke about 60,000 tonnes of sod peat at a 35% moisture content are required (about 450,000 m^3 in situ peat). To double production, double quantity of peat is required.

7.3 ACTIVATED CARBON

Approximately 90% of the activated carbon used in Canada is imported. The total annual Canadian market is approximately 5,000 tonnes and is worth about $8 million (1982). Due to the relatively small amounts consumed by a large number of industrites, Statistics Canada does not provide detailed consumption figures. The major uses of activated carbon are listed in Table 7.2.

TABLE 7.2: Uses of Activated Carbon

Process	Comments
-Sugar Refining	-Removal of small quantities of colour matter
-Effluent and waste water treatment	-Removal of organic matter -Removal of tastes and odors
-Insecticide manufacturers & electroplating industry	-Removal of toxins or other harmful chemicals
-Laundry & vehicle washing	-Removal of detergents
-Beverage industry breweries, wineries and soft drinks	-Removal of chlorine -Removal of contaminants
-Pharmaceuticals	-Removal of impurities -Preparation of chemicals
-Mineral recovery	-Trace elements captured by active carbons

The major user of activated carbon is the sugar-refining industry. In 1982, 2400 tonnes were consumed by this industry. In this application, the powdered liquid phase absorbent type of activated carbon is used. This is the least expensive grade costing an average $1.60/kg in 1982. The most expensive grades such as the extruded, hard, granular vapour phase adsorbents range up to $5.00/kg.

It would appear that the activated carbon market may be difficult to penetrate because the new manufacturers would have to compete with highly specialized world scale producers and their prices which at a small scale production might be difficult to match. However, the high value of activated carbon itself should be an incentive to consider its local manufacture.

7.4 DISTRICT HEATING OPTION

One way of avoiding the operational problems inherent in the individual home heating units (lack of experience in operating solid fuel furnaces, fuel storage, delivery and handling problems, user acceptance) is to consider a district heating system to service the entire community. In this case, only one heating centre is needed to produce heat and also hot water for the entire community. Practical experience elsewhere (especially in northern Europe) has shown that a district heating system is more efficient and environmentally less damaging than individual home units. Also such a large unit can be automated to a large degree and can be run by skilled operators and thus, avoid many of the problems the individual units have.

It is technically possible to set up small district heating schemes in remote communities, based on using local fuels, and to convert the homes to user systems which would accept heat distributed from a central heating station. While the costs of the heat transmission, distribution and user systems must be estimated on the basis of specific local conditions, it is possible to provide an indicative estimate of the cost of a small (1MW thermal) central heating plant for a district heating system on the following basis:

Main Fuel: wood chips, bark, sawdust, peat,
Auxiliary Fuel: propane, natural gas or oil,
Boiler: multiple solid-fuel boiler rated to provide 1 MW (thermal) into a hot water or glycol-water thermal system,
Fuel Silo: Live bottom 100 m^3 silo to store about 4 day fuel
Yard Storage: Depending upon seasonal fuel availability yard storage would be required along with suitable equipments such as a front end loader to reclaim fuel from the yard and to load it into the silo.
Pumping, Piping and Control System in the Central Heating Station: This system would circulate the heating medium into the transmission/distribution network and control the temperature and flow.

Auxiliary Fuel Storage: Propane, natural gas or oil would be stored and used for start-up and low load operation, or if the supply of solid fuel is disrupted.

The cost estimate given includes a provision for storage of auxiliary fuel adequate for 7 days' operation at maximum continuous rating. It is estimated that the described installation would cost about $1.0 to 1.3 million (in a southern Ontario location).

Assuming that the average design heat load per home is 30,000 kJ/hr, a 1 MW district heating installatin would heat 120 homes. If solid fuel is available locally at favourable rates, it may be worth reviewing such a plan site, specifically for Buffalo Narrows.

However, due to the early termination of the demonstration project, more mining tests would be required to accurately determine the cost of mining fuel peat to fire a control heating unit in order to more precisely calculate the total cost.

PART 8

ENVIRONMENTAL CONSIDERATIONS

PART 8 - ENVIRONMENTAL CONSIDERATIONS

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8-1 Inorganic sediment trapped by the vegetation at the mouth of the eastern perimeter ditch. 8-18

8-2 Inorganic sediment trapped by the vegetation at the mouth of the eastern perimeter ditch. 8-18

8.1 INTRODUCTION

Most of the work dealing with peatland utilization and its effect on the environment has concentrated on the effect of peatland drainage on the groundwater table. This aspect has been studied in detail, especially by European foresters in connection with the drainage of peatlands for forestry purposes. Recently, the possible physico-chemical effect of drainage, habitat changes, medical effect of peat dust on workers, possible air pollution by peat-fired utilities and environmentally acceptable reclamation procedures for mined-out peatland areas have been subjects of research.

There are distinct phases in peatland utilization which have somewhat different impacts on the environment. The major phases, such as pre-production, production, final use of peat and final land use, characteristic aspects, are discussed below.

8.2 DRAINAGE

821 DISCHARGE OF WATER

The first, and environmentally perhaps the most significant event in peat mining is draining of the deposit. The main purpose of drainage is to lower the water table in the peat deposit far enough below the surface to stabilize the surface layer sufficiently to support the operation of the mining equipment on the bog, as well as to enable drying of produced peat on the surface. Also, the purpose of perimeter ditches around the deposit is to cut off or reduce the recharge of the deposit by runoff from the surrounding peatlands or mineral terrain. All this may have an effect on the general hydrological conditions of the immediate surroundings of the deposit.

The mere existence of a peat deposit is an indication of a high groundwater table, either locally or regionally. The reasons for this are varied and include poor drainage, impervious soil types and a high water surplus. These are all factors involved in the formation of a peatland, in addition to other factors not pertinent in the present context.

A peat deposit has a groundwater system which may be directly connected to the general groundwater table, or it may have a perched groundwater table. The latter is a common feature of deposits where less humified peats are underlain by highly humified, impervious peats, and where the deposit is located on a flat or sloping surface, rather than in a depression. In these cases, the drainage of the bog would affect only the deposit itself without interfering with the surrounding terrain or its water table.

In the cases where the bog water table is part of the general water table of the adjacent terrain, a slight lowering of the level might occur. However, the drainage ditches are not excessively deep (usually from 1-2 m), since the aim is not to achieve maximum possible lowering of the water table. In fact, the optimum condition to carry out conventional dry mining techniques is to lower the water table near the ditches, 60-90 cm at most. With this lowering, and a suitable ditch spacing (e.g. 20 m) the drainage of peat between the ditches will be sufficient to lower the water table 10-30 cm in the centre of the fields. This is sufficient to increase the bearing capacity of the bog to carry standard mining equipment.

Additional lowering of the water table may, under certain condition in fact reduce the bearing capacity, and can also hamper the milling operations by allowing too thick a layer of surface peat to be broken down by the production machinery. With highly humified sedge peats, too dry a surface layer can also reduce the sodding capability of the peat.

The only visible effect of bog drainage is in the bog itself and in a narrow zone outside the perimeter ditch where increased aeration, through increased drainage, usually improves the growing conditions for vegetation. Where peatlands are very low-lying, the adjacent mineral terrain is often waterlogged by a high groundwater table. Under these conditions, drainage of the bog may lower the water table of the surrounding terrain. This is not expected to create environmental problems, except in cases where the ground should be left waterlogged for conservation purposes. Otherwise, drainage should be beneficial, as it allows improved forest growth and the use of the land for agriculture.

It is often said that peatlands act as water reservoirs and dampers against flooding. Generally, in areas where peatlands abound, there is no shortage of water, but rather there is a surplus. Usually peatlands are, and remain, saturated throughout the year without releasing much water even during the occasional dry period. This is due to the inherent water absorbing and holding capacity of most peats. Raw sphagnum peat can absorb up to 30 times its weight of water. Also, in cases where the surface peats become dry, recharge from the more humified, lower peat layers is generally very slow since the permeability of humified peats is close to that of some clays (Korpijaakko, M., 1974).

A natural peatland rarely has real significance in acting as a damper against floods since sudden rainfall runs quickly as surface runoff over the already saturated peat without being absorbed by it.

The quantity of water "lost" by drainage is negligible. About one year after the initiation of drainage, the water table will be established at its new level. Usually this is about 30 cm, on average, below the old level and equivalent to 1.4 month's rainfall in area such as Prince Albert, Saskatchewan and in parts of New

Brunswick. The total quantity of water removed per hectare may be up to 450,000 liters (100,000 gallons) and is a small quantity in comparison to the total environment for standard-size peat operations. The "loss" occurs only once as a guick release during the initial drainage, since the water table will not sink further than the pre-determined depth. After this the water table continues to sink slowly as the peat production progresses. This lowering is slow and is only 10-20 cm a year in a normal milled or sod peat production operation and is spread over the entire production season.

Detailed monitoring of peatlands in their natural state as well as under production has been carried out over a number of years in Europe. Measurements have shown that during the first 12 months after ditching the total discharge is about 300 mm higher than that calculated on the basis of meteorological and groundwater characteristics for an undrained bog. This appears to reflect the discharge of the storage within the limits of the drainage system as mentioned earlier (Sallantaus, 1983).

In areas that had been under production for a number of years, the measured discharge was equal to that calculated based on meteorological data indicating that the conditions had stabilized to pre-production level (Sallantaus 1983).

Short term peak discharges were large on occasion especially in areas with a high gradient and well-humified surface peat. This was most pronounced during high intensity short duration rainfall events. (Sallantaus 1983).

822 TRANSPORT OF SOLIDS

Depending on the mining method, varying quantities of fine peat can be transported by the drainage ditches from the bog to the surrounding waters. Research has shown that in the areas of older peat operations, the peat silt transport (under normal conditions) does not appear to be significant (Korpijaakko et al 1976). However, newly opened drains, full of water, can carry large quantities of solids into surrounding waters for a short time period. Also, very few solids are transported from the deposit in its natural state. During the ditching, silt quantities may be considerable during the initial discharge peak flow. In production areas, heavy rainfalls exceeding the surface discharge threshold are the main cause of the increased transport of solids (Sallantaus 1983). The steeper the invert gradient of the ditches, the greater and the more coarse in size are the transported quantities of solids after heavy rainfalls. In one case, on a Finnish peatland developed for fuel peat production, up to 26 kg/ha/hr of measured solids were transported from a deposit during a heavy cloudburst. In this area, the average yearly transport was measured at 300 kg/ha and comprised mostly of organic matter.

At the same location, one of the most conspicuous, measured transport of solids events was during the spring run-off when up to 6000 kg/ha of silt was eroded from the perimeter ditch and deposited in the nearby water (Sallantaus 1983). However, the influence of the inorganic, heavy silt, with its high density, on the ecology of the waters is less deleterious than that of organic solids which require vastly larger volumes for sedimentation and may cause oxygen deficiency and other side effects in the receiving waters. The inorganic silting can be reduced by utilizing proper ditching procedures, avoiding ditching during high discharge periods and by using sedimentation ponds and traps. The organic silting is best avoided by sedimentation ponds, keeping the ditch gradient low and by letting the water drain onto an undrained land area whenever possible to allow the silt to settle.

Figures 8-1 and 8-2 show silting at the mouth of the eastern perimeter ditch at the demonstration site. In this case, the ditch ends on a flat edge of an adjacent bog. The vegetation has trapped all the silt within a few hundred square meter area from the discharge point, without any danger of the silt entering the waterways.

823 TRANSPORT OF DISSOLVED ORGANICS

The quantity of dissolved organic matter in the discharge water of ditched and natural peatlands appears to be the same (about 60 mg O/L, COD - Mm value) in general. Studies in Europe have shown that the (efficient) ditching and contouring of the production fields increases the surface run-off in the spring so that most of it takes place before the peat thaws. As a result, minimal dissolved organics escape and the overall quantities are lower than in virgin peatlands where run-off continues strongly after the peat has thawed out allowing dissolved organics to be transported from the deposit. The net result, especially following winters with large quantities of snow, is a decreased quantity of dissolved organics from the drained peatlands in contrast to those in their natural state.

824 pH OF DISCHARGE WATER

Most peatlands are quite acidic in nature. Typically the pH of ombrotrophic sphagnum bogs varies between 3 and 4.5, while in the more eutrophic peatland areas it is commonly between 4 and 5 and occasionally in limestone areas, it may even be neutral. The low pH values are caused by the weak, well-buffered acids present in peat. Because the acids are weak, their effect on fish is insignificant. Research has shown that, under normal conditions, the acid bog waters appear to have no harmful effect on, for example, Salmonidae fish or on their spawning efficiency.

Monitoring of the pH of discharge water has shown the situation to be quite complex. Typically, the drainage initially discharges surface water which is usually more acid than that drained from the greater depths. However, when later deepened, the drainage ditches, reach the more minerotrophic peats at greater depths with a higher pH value. As a result, soon after initial drainage, the pH values in fact have been found to be higher than expected. In some cases, the pH values of the surface water have been about 4 while that of the discharge water have been 5-6 largely due to the discharge originating from the eutrophic layers below the surface. Thus, in the long run, the drainage in the vicinity of the production fields may actually have a neutralizing effect in comparison to the natural deposit where the water movement takes place in the acid surface layers. Only during high peak surface run-off periods the pH values become lowered because of the effect of the acid surface water.

825 NUTRIENT RELEASE

The nitrogen content of peat is relatively high. From virgin peatlands, only small quantities of eutrofying, inorganic nitrogen is leached out. Field observations (Sallantaus, 1983) have revealed that drainage increases this leaching considerably. The values may increase up to 4.6-8.5 kg N/ha annually increasing the eutrophication danger of the receiving waters. However, usually this is much less significant than leaching from, e.g., large farms.

Another important factor in the eutrification process is phosphorous. As a rule, it has been observed that the leaching of phosphorous from drained peatlands is less than from fertilized farmland, being of the order of 1.2 kg P/ha initially and decreasing later. The highest concentrations are during the dry periods and the lowest during the drainage peaks. Phosphorous content also increases with depth as the mining operations reach the more eutrophic peats underlying those on the surface.

In summary, it can be stated that in comparison with the general pollution load, the amount caused by peat operations appears to be insignificant. Peat-related pollution can be minimized by carrying out the drainage work during the time when the run-off is minimal, by controlling the flow in the ditches either with weirs or gentle gradients or by adding sedimentation ponds and terminating discharge ditches in a buffer zone where the vegetation can filter out the pollutants before the discharge waters reach the main water courses (Figures 8-1 and 8-29).

8.3 PEAT DUST

831 QUANTITIES

In milled peat operations, up to 20% of the production volume can occasionally be carried away by strong winds. A heavy dust can be a nuisance in nearby towns and villages. However, most peat operations are remote from the larger population centres, minimizing the nuisance from airborne peat dust.

As this loss is also an economic loss to the operation, an incentive, even without regulations, exists to minimize it. Proper mine planning, drainage and storage methods, taking into consideration the direction of the prevailing winds, help considerably in reducing the wind loss and the consequent nuisance to the local inhabitants.

Studies in the USSR have shown that when the moisture content of peat is raised from 11% to 50% the critical wind velocity (the velocity at which the peat starts being lost to the wind) increased from 4.7 m/s (17 km/hr) to 9.2 m/s (33 km/hr). The dusting loss increases significantly with a decrease in the moisture content. If the moisture content of the top layer is over 50% there is no appreciable erosion at wind speeds of 12 m/s (43 km/hr) or less (Gavriltsik, A.P. et al, 1982).

Studies in Finland have shown that at dust collection stations located adjacent to the production fields, dust sediment quantities varied, being usually less than the recommended maximum of 10 g/m^2/month. The measurements were carried out over one month periods and gave only monthly averages, and may not necessarily show occasional individual heavy concentrations contributing to the total, occurrences that may be a nuisance regardless of the overall low monthly sedimentation.

Dust was measured at sites where the Haku mining method, vacuum collection method and sod production were utilized as well as in the surroundings of a peat-fired power station. The monthly dust accumulation at a site using the Haku mining method varied from 0.41 g/m^2/mo. to 51.91 g/m^2/mo. averaging 6.55 g/m^2/mo. The degree of humification varied from H3 to H6 and the ash content from 1.8 to 10.9% (average 4.4%) (Vesterinen 1983).

At a site where the vacuum collection method was used, the dust accumulation immediately adjacent to the production field on a newly-opened bog with a high (656 m^3/ha) production volume varied from 1.91 g/m^2/mo. to 38.55 g/m^2/mo., averaging 13.58 g/m^2/mo. and at an older bog with a lower (470 m^3/ha) production volume varied from 0.63 g/m^2/mo. to 27.98 g/m^2/mo., averaging 6.46 g/m^2/mo. The newly opened bog had a surficial peat layer of H2 to H5, which also initally increases the dust emission in contrast to more humified peats.

Measurements on a sod peat production field gave values varying from 0.17 g/m^2/mo. to 15.84 g/m^2/mo. and averaging 4.00 g/m^2/mo. The degree of humification was H5 to H7 and the ash content 4.7 to 12.7%. The values for sod peat are lower than those for milled peat mainly because there are only small quantities of fines produced during the sodding operation.

Measurements done near a peat-fired power station revealed the peat dust accumulation to vary from 1.75 to 30.88 g/m^2/mo. (average 8.23 g/m^2/mo.) while at distances of 500-700 m from the storage area the concentration was lower, 1.23 to 12.44 g/m^2/mo. (average 4.8 g/m^2/mo.) (Vesterinen, 1983).

The above readings show that the dust emission is lower in a sod peat production area than in a milled peat area. Also, it reveals that the dust accumulation around a peat-fired power plant is low and decreases quickly with the distance. However, the readings may vary from site to site and depend largely on the peat type, degree of humification, mining method, storage method and on the weather parameters such as wind and relative humidity and should, in any case, be measured separately for each specific site.

832 MEDICAL EFFECT OF PEAT DUST

Until recently, almost no attention was paid to the possible health hazards of peat dust. Apart from eye and nose irritation, it was believed that peat dust caused no other problems. Recently, studies have shown that prolonged exposure to peat dust (in high concentrations at the work site) may be a cause of a number of mild respiratory and skin ailments (Riihimaki et al, 1980). Research has not been done yet to establish the levels at which peat dust, in the immediate vicinity of a peat mining operation may be hazardous.

833 EFFECT ON ADJACENT ENVIRONMENT

The addition of organic matter to the immediate environment surrounding the bog, as windborne peat dust, is usually of a very diluted nature. At the edges of the bog there are sometimes greater quantities of peat dust covering the ground, up to a few centimeters. The denser vegetation on the mineral terrain effectively filters most of the peat dust within the first few hundred feet of the bog. Particles flying higher with the wind may be carried varying distances. In most cases it will be distributed over such large areas that the influence on the ecological balance is negligible. In many cases, the mineral soil is poor in organic matter and this small added quantity of material is welcomed. The prevailing wind direction in the Buffalo Narrows area is expected to carry any airborne dust the demonstration site location away from the community. The readings given above indicate that in the case of a small operation such as the one at Buffalo Narrows the dust accumulation would be expected to be below 10 $g/m^2/mo$ and occur only during the production season.

8.4 AIR POLLUTION

841 GENERAL

While air pollution caused by peat mining directly is negligible or short-term, and restricted to especially windy periods in the form of wind-borne dust, the pollution from stacks or chimneys by the user may be more significant. As a rule, peat is a very clean-burning fuel, compared with some oils and coals. The following is a brief account of the main possible sources of air pollution when using peat as a fuel.

842 VOLATILES

Peat commonly contains 60-70% volatile matter. The Finnish peat-fired domestic furnaces have been designed to minimize the amount of unburned volatiles escaping with the flue gas. However, further tests will be required both on the Canadian and Finnish models to determine their effectiveness when burning peat in the actual home heating conditions, and firebox conversions may be required at least for the Canadian furnaces. The use of peat as a fuel in the small domestic furnaces, such as planned in the Buffalo Narrows area, is not expected to create as much of an environmental problem as a nuisance, caused dry peaty odor in case the volatiles are incompletely burned because of a small size of the community. The percentage of volatiles in the peat in the demonstration bog (69-73%) is quite high as far as average values for peat are concerned.

843 SULPHUR

One of the most undesirable pollutants in fossil fuels is sulphur. High concentrations of sulphur in fuel results in high sulphur emissions and require extensive scrubbing equipment to meet the demands of an environmentally acceptable operation. Fortunately, peat is often a suitable fuel since its sulphur content is commonly 0.1-0.2% (of dry matter) or even less, if calculated on the basis of wet weight of peat (about 50% moisture content) as delivered to the user. The sulphur content of the peat at the demonstration bog is 0.1-0.15% and falls within the normal average values.

844 OTHER ELEMENTS

The element analyses of the peats in the Buffalo Narrows region show no significantly anomalously high concentrations. Queries were made by SEM regarding the levels of mercury encountered during sampling, whether they were higher than normal. For this reason, mercury was analysed in the demonstration bog samples to supplement the analyses done by SEM on the peats in this region.

The mercury content varied between 0.05 and 0.07 ppm in the demonstration bog peat (on the basis of dry weight). Values recorded in the literature for Finnish peats show 0.012 to 0.4 (on average 0.13 ppm) (m. Bysiek et al 1974), and 0.06 to 0.3 ppm in Canadian peat

(Jonasson and Boyle, 1971). The values for the demonstration bog are at the lower end of the scale, for the Canadian peats. In comparison with mercury values for other fossil fuels the peat values are very low. The mercury contents of different coals varied from 0.01 to 300 ppm (Jonasson and Boyle, 1971) and for a number of American coals 3.3 ppm (Joensuu, 1971). Average mercury values for petroleum products originating in California ranged between 1.9-21 ppm (Jonasson and Boyle, 1971).

The absolute values of mercury in different fuels should be related to their calorific values when considering the potential of the fuels as sources of mercury released to the atmosphere. Dividing the mercury concentration by calorific values, for Finnish and Buffalo Narrows, Saskatchewan peats and Polish and Russian coals and Californian oil (data readily available from the literature), the following ratios are obtained in ug and ng of Hg/kcal.

a) Peat:

- Finnish

$$\frac{\text{127 ug Hg/kg}}{\text{5050 kcal/kg}} = \text{25.3 ng Hg/kcal}$$

- Buffalo Narrows, Saskatchewan

$$\frac{\text{55 ug Hg/kg}}{\text{5393 kcal/kg}} = \text{10.2 ng Hg/kcal}$$

b) Petroleum:

- California, U.S.A.

$$\frac{\text{1900 ug Hg/kg}}{\text{10,000 kcal/kg}} \text{ to } \frac{\text{21,000 ug Hg/kg}}{\text{10,000 kcal/kg}}$$

$$= \text{190 to 2100 ng Hg/kcal}$$

c) Coals:

$$\frac{\text{200 ug Hg/kg}}{\text{6300 kcal/kg}} = \text{31.7 ng Hg/kcal}$$

On the basis of energy produced, the values for peat are low, especially when compared with oil. If one considers the actual quantity of energy proposed to be produced from peat in the Buffalo Narrows region, the mercury fall-out would not likely be detectable, and certainly could be expected to fall far below that produced by the existing oil-fired furnaces. Also the mercury levels of the peat in the Buffalo Narrows area are considerably lower than those on average elsewhere in Canada or those measured in Finland, for peat used as fuel.

8.5 HABITAT CHANGE

The most conspicuous impact a peat mining operation has on environment is to change the nature of the deposit being mined. Draining, subsequent stripping of vegetation and slow removal of peat changes the peatland habitat from a natural one to a cultural one in a manner similar to converting land to agriculture. The change of peatland habitat is total and nothing of the old habitat, except the peat deposit, is left. This change may appear objectionable from the point of view of preserving the original landform. However, from the point of view of land use, it is beneficial.

In a biological sense, a typical Canadian peatland with thick peat layers (1 m or more) and open vegetation is quite unproductive. It also offers a living habitat to relatively small populations of animals in comparison to the mineral terrain with a varying vegetal cover. Parts of the peatlands (the edges of the bogs and the shallow eutrophic peatlands) are biologically productive. However, these areas are not taken into use and do not suffer from the peat mining operations. The drainage of the peatland proper, actually can enhance the growth of vegetation near, and at its edges, creating habitats that may be more suitable for deer and moose than previously.

At present, a very small fraction of the peatlands have been taken into use, and there is no danger of obliterating this unique habitat. Also a number of national and provincial parks contain large representative peatland areas conserved and protected from exploitation. The IBP (International Biological Program) project Telma is compiling a list of Canadian peatlands with unique features to be protected from use, ensuring the natural peatland areas will be left untouched.

8.6 FINAL LAND USE

The final land use refers to the use of the peat deposit after active mining has been completed. The final land use should be considered during the planning phases of the mining operations. There are several options for final land use, including reclamation of the area for agriculture, for silviculture, for recreational use, or alternatively, letting it revert back to its original state.

With present mining methods, peatlands are carefully levèlled, and profiled and the peat is removed in thin layers. This leaves the abandoned peat mining areas flat and suitable for both agricultural or forestry purposes. The standard 20 m ditch interval conforms to such uses. Usually 1/2 to one meter of peat is left above the underlying mineral terrain and forms a suitable organic growing medium, in close enough contact with the underlying mineral soils, to be sufficiently eutrophic for most crops, with a minimum of fertilizing. In Europe, reclamation of both virgin and used peatlands has been successfully carried out for both agricultural and forestry purposes, and such is expected to be the case in the Buffalo Narrows area also.

If the region where the mining operation is located is considered too remote for agriculture or forestry, or for some other reason is not suitable for the above mentioned purposes, it could be taken for recreational use or allowed to revert to its original condition. It may never attain its original state, but, depending on local conditions, will return to some form of peatland system.

8.7 FUTURE USE OF THE DEMONSTRATION BOG

Depending on the financial arrangements, there are a number of options available for the immediate future regarding what can or should be done with the demonstration bog. If a decision is taken to use the bog for further work, depending on how soon it may be taken into use, the drainage system should be maintained. If the ditches are left as they are currently, they will slowly become silted in and blocked by material sloughing in from the edges of the ditches and by the re-growth of vegetation. However, if circumstances do not allow maintenance of the ditch system, it should be understood that later recutting of the ditches may be more costly and also that the blocked drains will allow the bog to become wet again delaying its preparation for fuel or other use possibly by a full year.

In order to avoid aforementioned kinds of problems, the ditches should be cleaned carefully and especially the perimeter ditch if continued drainage is to be ensured. In order to avoid excessive lowering of the water table while the bog is not in use, with the ensuing oxidization of peat, the water level in the field ditches should be kept at about 30 cm from the surface by installing small weirs at the ends of the ditches.

There is some horticultural peat on the surface of the demonstration bog. It may be of local interest and could be used as a soil conditioner in the nearby communities. It would be a relatively simple operation to collect the surficial peat which has been piled by a screw profiler on each production field. If this is considered the first activity would be to clean the ditches after the snow has thawed to ensure drier bog conditions.

If the deposit is not going to be used at all, a distinct possibility is that the ditches could be left as they are or they could be blocked and even partially refilled. In the case where the ditches were left unattended they would, over a number of years, totally cease to function and the deposit would slowly return at least partially, to its former state. However, the open ditches may pose a possible danger both to an unsuspecting hunter and to wildlife and it would be prudent to block the ditches and at least partially fill in the perimeter ditch. This also would accelerate the re-paludification process and would be more agreeable also from the aesthetic point of view. Also the blocking of the ditches accelerates their filling in by vegetation and thus reduces the potential danger.

Figure 8-1. Inorganic sediment dropped by vegetation at the mouth of the eastern perimeter ditch.

Figure 8-2. Inorganic sediment trapped by vegetation at the mouth of eastern perimeter ditch.

APPENDIX A

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